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The General Flexure of Straight Beams.

Any suitable analytical treatment of a matter so frequently found in the practice of the engineer as the flexure of beams can scarcely fail to elicit something, and perhaps much, of practical importance. The general theory of flexure has no doubt been as thoroughly set forth as any single theory used by the engineer at the present time, and yet every student in engineering science knows that the case is not complete. As in many other purely technical matters, the Germans have been pioneers in the mathematical treatment of this subject from Clebsch or earlier down to the present time. Nevertheless, there is yet room for further advances. The paper by Prof. L. J. Johnson, read before the American Society of Civil Engineers on April 18, is a distinct contribution to the literature of bending in beams. The title indicates the paper to be "a complete analysis of general flexure in a straight bar of uniform cross-section." It is no reflection upon either the thoroughness of treatment or the real value of the paper to observe that the analysis as a theory of flexure can scarcely be considered "cimplete," for the reason that the fundamental law of the common theory of flexure, i. e., that the intensity of the stresses of tension and compression varies as the distance from the neutral axis, is assumed and not demonstrated. This assumption has so long and so frequently been made that students as well as practicing engineers accept it as a kind of scientific revelation without examination. Although it is not worth while to be hypercritical on such points, there is practical importance in knowing always the real ground of an engineer's practice. It is true that this law is so simple and so nearly the truth, and is the origin of so much that is of the greatest possible value in the design of all kinds of beams or girders, that no reasonable man will question the advisability of its use in all sorts and kinds of beams, yet there are some questions of structural design in which it is of the utmost practical importance to be thoroughly informed as to the ultimate analytic basis of this assumption. Structural engineers even have many times made unpardonable blunders, professionally speaking, in consequence of their lack of knowledge as to the real nature and theoretic basis of the common theory of flexure. Mr. Johnson's "complete" analysis of general flexure, therefore, must be taken as being directly applicable only to long beams.

In the simplest terms, he has applied the common theory of flexure in a most admirable manner to long beams of sections unsymmetrical about axes parallel to the plane of loading. He correctly observes that in the ordinary use of the common theory of flexure the neutral axis of any normal section is always assumed to be at right angles to the plane of loads, which ceases to be true when the plane of loading is not a plane of symmetry of the section. He recognizes the fact that beams as such are designed almost without exception to meet the condition of symmetry of section, but on the other hand there are cases of light beams, such as Z bars, angles and other special forms, where the symmetrical relation no longer holds. The equations derived by Mr. Johnson are so formed as to give a correct solution for these special cases in a comparatively simple manner. It is doubtful whether engineers in general will take kindly to material departures from their regular procedure of design in these comparatively light cross-sections even when the change involves but a slightly more complicated analysis and a little more work of computation, although it would sometimes be better if they regarded such changes as less formidable.

What is probably more needed in a treatment of the theory of flexure than an extension of refined analysis to rare cases is investigation regarding the inter-relations of the stresses of shear, tension and compression in beams having the cross-sections generally used. There are, for instance, various theoretical considerations on which the design of the webs of plate girders is based, but the knowledge of the distribution of stress throughout the mass of such webs is still lamentably incomplete. Again, in solid short beams like the pins in pin-connected bridges, and even in such solid beams as those of timber, the rationality of design would be greatly enhanced if more were really known of the actual stress conditions throughout the masses of such members. While, therefore, Mr. Johnson's paper is a distinct contribution to the theory of flexure, there is still ample room for the work of further investigation before the general problem can be considered solved with a satisfactory degree of approximation.

Engineering Reports as Advertisements.

The consulting engineer who has worked up a good business without having seen at least one of his reports used for advertising purposes or bolstering bond issues is to be congratulated. The lyric star whose name is given to cigars and the professional "society" chaperon who furnishes a recommendation for tooth powder are paid for the use of their names in advertising matter; nobody is deceived as to the value of the recommendation in such a case. But an engineer who reports confidentially on some engineering appliance or process is rightly disturbed to find extracts from his report of a favorable character used for advertising purposes, while those of an unfavorable character are withheld. This misuse of his report may make it appear that the engineer endorses the appliances or process when, in reality, quite the contrary may be true. The act is very different from the mere abstracting of certain parts of a report in preference to its publication as a whole. The interested parties who distort such a document really commit an act of fraud, for it brings to the public eye certain things ostensibly supported by authority which, in point of fact, does not exist. Every disinterested man should frown upon this practice, not only for the moral question involved, but for the injury to the engineer who is thus misrepresented.

As an instance of what has been done, take the case of a manufacturer of steam appliances who made a contract with a mill for the remodeling of a boiler plant and the attachment of certain apparatus for the alleged better combustion of the coal, and made a guarantee that he would save on the total quantity of coal burned 30 per cent. of the cost of his present fuel; the decision as to the fulfillment of the guarantee being left to an expert who was to test the fuel consumption both before and after the appliance was attached. The steam appliance man noticed that the fireman was inefficient. There were certain leaks about the steam plant and certain wastes that could easily be remedied; and, furthermore, the class of fuel was of an expensive character. In a word, there were opportunities to make various improvements with little or no reconstruction, that would, in themselves, secure a considerable saving in the cost of operation. The coal consumption and the cost of fuel per horse-power per hour were determined by the expert, and the new appliance was attached and preparations were made for the second trial to ascertain the fulfillment of the contract. In the meantime the fuel was changed to one which was nearly as efficient, but far less expensive, some insignificant changes made in piping, and some of the fittings were changed by which the leaks and wastes spoken of were remedied, the fireman was instructed in the proper management of the boilers, all being done at the suggestion of the party who put in the appliance. Then the test was repeated. When the result had been determined it was found that the cost of fuel was not only reduced to the extent of the guarantee, but 5 per cent. more; and the expert reported to his clients accordingly. The expert stated in his report the condition of the plant before the appliance was attached, and after its installation; and, furthermore, made note of the changes that had been made, and summed the whole up by stating that the aggregate saving was 35 per cent. Thereupon the steam appliance people published an extract from the expert's report to the effect that the application of the appliance had resulted in a saving of 35 per cent. and conveyed the impression to the public that, upon the authority of the expert in question, the efficiency of the appliance was represented by this saving. The facts were that a large part of the improvement was produced by the simple change in the kind of coal burned to one of a cheaper class, and nearly the whole of the remainder was due to the improvement in firing and the prevention of wastes that were going on before that time; in point of fact, the appliance produced barely any improvement whatever.

Engineers may ask how this misuse of a report can be stopped, inasmuch the manufacturer has paid for it to use it as he sees fit. That is true only in part; he can suppress it, of course, or publish it, but he has no right to use an engineer's name to mislead the public for his own profit. It is the privilege and should be the duty of every engineer whose reports are garbled so as to mislead or deceive, to call public attention to the fact. If the engineer fails to do so, the public will rightly conclude he was paid to make a report with that object in view. A few exposures will be quite effective in putting a stop to this practice.

The Vibration of Tall Buildings.

There is no single feature of last week's catastrophe in California of higher technical interest than the resistance of structures of the best modern design to the severe earthquakes which brought havoc to a strip of coast several hundred miles long. At Leland Stanford Jr. University some of the best of the concrete buildings, notably those constructed by Mr. E. L. Ransome, were uninjured, while other structures were more or less damaged. This is not at all surprising because some of the buildings that failed were architecturally unsuited to resist a severe shaking while among those which were uninjured are buildings designed specially to withstand earthquakes. It is unjust to judge the value of various building materials by the effect of the shocks of last week unless attention is paid at the same time to the designs of the structures in which they were used. A good material may be used in such a way that it offers little resistance to fire and earthquake, while skillful design may produce far better results, considered from the point of view of stability alone, with building materials of a relatively lower character. It is on this account that the information to be gained from the present condition of masonry structures, particularly those of concrete, can be accepted only after the closest scrutiny. Particular attention should be called in this connection to the valuable articles by the late George W. Percy on various important concrete and reinforced concrete buildings in California, printed in this journal on March 24, 1894, and June 17, 1899.

While it is impossible to form now any accurate judgment of the detailed resistance offered to earthquake by concrete structures, the admirable manner in which steel cage construction of a good character withstood the earthquakes is manifest. The most conspicuous structure of this type in the city, the Spreckels Building, where the "Call" had some of its offices, was injured only by fire. This building was a remarkable structure, as may be seen from the description of it in this journal on April 9 and 16, 1898, and the manner in which it withstood the shocks is most gratifying. The same is true of the condition of other steel-cage buildings of less height but greater area. Many of these were specially designed to resist earthquakes, and the fact that in some cases they were supported on material not particularly favorable for office building sites makes their recent resistance to violent vibration all the more remarkable.

Accurate observations of the vibrations of tall buildings are extremely rare. Among the few of them mention may be made of those by Mr. W. L. Stebbings in the Monadnock Block and Pontiac Building, of Chicago, during a high windstorm about eight years ago. His first observation was in the Monadnock Block and was made by a plumb line in the stair well reaching from the sixteenth down to the second floor. After the plumb line was released from its initial twist sufficiently to allow the bob to move under the direct tension on the string, the bob described a circle approximately one-half inch in diameter while moving under the swaying motion of the building caused by the wind. This observation was made with the point of the plumb bob about one-sixteenth of an inch above a sheet of paper on a drawing board. When this observation was repeated in the south stair well of the same building from the seventeenth floor the point of the bob described an elliptical path with an axis of seven-sixteenths of an inch in one direction and three-eighths of an inch at right angles to the first. The next observation of precisely the same character was made in the Pontiac Building with the plumb line extending from the fourteenth down to the first floor. The elliptical path of the point of the plumb bob in this case had axes of three-eighths and one-fourth inch. Mr. Stebbings was of the opinion that this building was protected by the adjoining Elsworth Building, since it did not receive the full force of the wind.

It is, of course, a matter of doubt whether the motion of the plumb bob in such a case indicates the real motion of the building in its true magnitude, although it certainly would not oscillate if the building had no motion. Mr. Stebbings realized that this might be the case and therefore made transit observations from a completely protected position on the northwest and southwest corners of the Monadnock Block. At the northwest corner he found an extreme vibration of one-fourth of an inch, and one-half an inch at the southwest corner. During the progress of these observations the velocity of the wind, as gauged by the usual conventional methods, varied from 60 to 70 miles per hour, and at least a dozen wagons were overturned at the southeast corner of the building during the day.

These tests cannot be considered conclusive as to the actual motion described by the buildings under the action of the winds to which they were subjected, for the path described by the plumb bob is probably not just that traversed by the upper extremity of the line to which it was attached. Yet inasmuch as the observations extended over a considerable period of time, it is certain that had the upper parts of the buildings any great amount of motion the plumb bob would have described a correspondingly increased path. The fact that the latter was small may be taken as showing that the wind produced a series of correspondingly small effects, and this conclusion is confirmed by the observations with the transit.

The vibrations due to the earthquake were much greater, sufficient to toss people about in the rooms of some of the well-built hotels. Unfortunately, it takes very little jarring of a platform to produce this effect. A shaking of but a very few inches on the movable stairs at summer resorts makes their ascent and descent a very trying feat. It is impossible, therefore, to estimate from the statements of people who were in San Francisco during the earthquakes what was the amplitude of vibration of the important buildings. The pendulum of the seismograph of Prof. George Davidson, Hon. M. Am. Soc. C. E., was thrown off the register, indicating that the motion was very violent. On the other hand, the enormous masses of the larger office buildings probably operated to keep the vibration in them below that in the rows of flimsy tenement houses on the unstable filled ground to the east of them. While opinions concerning details of design cannot be formed in the light of present knowledge, it is certain that the steel-cage framing used in the better class of buildings has demonstrated its suitability for a city exposed to earth tremors and shocks. The problems of wall and floor construction alone are debatable.

Jarring in Steam Pipes.

There is nothing more noticeable in the operation of most steam plants, even in those arranged according to approved methods, than the tendency to vibrate of the pipes conveying steam to a working engine. Unless the pipes are securely braced by tie-rods to some rigid part of the building, the vibrations may become so great as to be almost dangerous, and not infrequently it proves impossible to anchor the pipes in a manner to overcome movement entirely. These vibrations are not produced by any movement of the engine itself, for however rigidly the body of the engine is secured to its foundations and however strong and stable the cylinders, the motion of the pipes is sure to occur. It is true that the pipes may be set in vibration to some extent by a cylinder which is not itself secure, but which partakes of the reciprocations of the engine. The serious vibrations are due to an entirely different cause, however, the effect produced by the peculiar motion of the steam itself within the pipe, caused by the intermittent character of the discharge of steam into the engine cylinder. A steam gauge attached to the main supply pipe of the engine, if wide open, will show so much fluctuation, occuring in unison with the reciprocations of the engine, as to endanger the working parts of the gauge. An indicator applied to a steam pipe will show a series of undulations, as it were, in the pressure, also in unison with the movement of the engine. The steam-pipe diagram, in a case where there are numerous bends between the boiler and the engine, will reveal a variation of pressure amounting possibly to 10 lb. for every revolution of the engine, although the supply pipe may be what is considered ample in size. These instruments show that the movement of steam through the pipe to the engine does not occur in a steady flow, but rather by a series of pulsations, the current being arrested every time the cut-off valve is shut and set in motion again whenever the valve is open. The effect produced by this intermittent current is to cause the pipe to rebound wherever the direction of the current is changed, as occurs where the steam passes through an elbow. A force is thus applied in the direction of its length on every section of the pipe, and the pipe must be braced at every angle in order to withstand it. The trouble is most active where slow-speed engines are in use, the pulsations occurring here at comparatively long intervals of time.

This is a remedy which may be applied to reduce, if not entirely prevent, this evil. The vibrations of the pipes are injurious not only to the structures against which they are braced, but also to the pipes themselves, or rather to the points which connect the various sections of the pipe together. They do injury also to the engine at one end of the line and to the boilers at the other end, if the pipes are not held with a sufficient amount of rigidity to prevent all movement at these points. The remedy is to place near the engine a reservoir into which the steam is first supplied as it is delivered from the boiler, and feed the engine with a pipe leading from this reservoir. The larger the reservoir compared with the volume of the cylinder, the better is the result. With this arrangement the steam is first drawn from the reservoir, and the excessive fluctuations of pressure due to the intermittent supply to the engine are confined to the pipe which leads from the reservoir to the engine. There is a sufficient amount of steam stored in the reservoir to prevent much fluctuation of pressure there, and the flow of steam into it from the boilers occurs in an approximately continuous current, where before it was intermittent. This method of preventing vibrations of pipes has been growing in favor slowly, and where it has been applied there is a most satisfactory absence of the jarring.

The Niagara Falls Problem.

It is not at all unlikely that the full extent of the complications likely to arise from much further diversion of water from Niagara Falls is unappreciated, even by those who have given some attention to a few features of the subject. The aesthetic objection to reducing any part of the Falls to a thin sheet of spray or a wall of rock is unanswerable, yet there is manifestly an equally strong argument to be made for the utilization of the power of the plunging waters for the benefit of many communities in this country and Canada. The counterbalancing of these two arguments, so as to be just to both in a decision concerning them, is a task to which nobody desires to be condemned. It offers no attractive honor, nothing but the certainty of hard work and much abuse. This vituperation will come from the so-called artistic classes, who have such a continuous practice in criticising each other's work that when they all unite in hurling anathemas at the Philistine, the latter must be brave indeed to stand his ground. This talk about destroying the beauty of the Falls has a ridiculous side, moreover, which the unartistic mind of the average legislator thoroughly appreciates. It is difficult to find a place in the country less attractive than Niagara Falls from most points of view. Enormous signs, hideous hotels, and other monstrosities frame the picture of the rushing waters in such a way that the general impression of the place is that of a cheap Coney Island rather than a stupendous natural spectacle. Theoretically the latter may exist, but practically it does not except in a debased and bedraggled form. Consequently it is going to be a very uphill fight for the organizations which aim to prevent, for æsthetic reasons, any further development of power at this place.

The value of the power that can be developed at the Falls is likely to be a cause of contention for two reasons. If the diversion of water were prohibited, the value of the franchises already granted would be materially increased, for the power from the Falls would then be sold in competition with coal alone. Under such conditions the chartered companies would unquestionably divide the business and, by avoiding competition among themselves, earn enormous sums. These profits would result in great influence being brought to bear to secure charters for new companies, and the financial stake would be so great that unquestionably new projects would be sanctioned sooner or later. The public opinion which is not strong enough to prevent the general desecration of the surrounding of the Falls is surely not strong enough to prevent on aesthetic grounds the utilization of a very large part of the water of the river for power purposes of marked industrial and commercial value to large American and Canadian districts.

While there will be a vigorous struggle for franchises to develop power at Niagara Falls, another source of contention exists in the international ownership of the Niagara River, and the lack of certainty concerning the jurisdiction of State, Province, Nation and Dominion. This is specifically referred to by the members of the Canadian Section of the International Waterways Commission in their first report as follows: "A very large portion of the power generated on our side of the river at Niagara will, unless some more effectual restrictions are placed upon its removal, soon be permanently diverted to the building up of American factories and the running of American railways. Within a few years our own railways will be clamoring for this power. Vested rights already interfere with action in this regard, and the more power that is now allowed to be diverted the greater will be the evil and the harder to rectify." This complication over water rights and the exportation of electricity is apparently regarded by the Canadian members of Commission as more serious than the prohibition of further diversion of the water. Now that the cities of Ontario have awakened to the value of power from Niagara as a means of extending their industries, it seems unlikely that a duplication of some of the provisions in existing Canadian franchises will ever occur. Even without this duplication, however, the complications likely to arise are so serious that a special elaborate investigation of the entire subject of water rights and power development should be made by an international commission. The various interests concerned can only thus receive the complete impartial hearing they deserve. At the present time a careful critical study of existing conditions and tendencies is very much needed to counteract the specious arguments that are beginning to appear for different methods of handling the complicated problems presented at the Falls.

Notes and Comments.

THE LARGEST GASHOLDER in the country and possibly in the world is said to be that under construction at the Astoria works of the Consolidated Gas Co. of New York. It is 300 ft. in diameter and will rise to a height of 260 ft. when fully inflated. Its capacity will be 15,000,000 cu. ft.

THE ONTARIO MUNICIPAL POWER PROJECT recently investigated by a commission representing Toronto, London, Brantford, Stratford, Woodstock, Ingersoll and Guelph calls for a subterranean power house immediately opposite the plant of the Niagara Falls Park & Railway Co., with transmission lines to the cities named and eleven more. About 81,000 h.-p. is needed by these cities, the commission estimates, and it has accordingly planned a station of 100,000 h.-p., costing nearly $12,000,000 with transmission lines. The cost per horse-power per year at the municipal switchboards is estimated on a 24-hour basis from about $9 to $25, depending on their location. The sale of this power is considered of vital importance to the industrial growth of the cities.

A REINFORCED CONCRETE RETAINING WALL of unusual cross-section has been designed by City Engineer E. A. Harper, of Kansas City. The typical section has a base 12½ ft. wide and 3 ft. thick carried by four rows of piles which have their heads buried about 1 ft. in the concrete. A few inches above the tops of the piles there is a network of ¾-in. transverse bars and ⅝-in. longitudinal bars, both on 12-in. centers. Above this base the wall is stepped back on both faces until it has a thickness of only 21 in. at a height of 10 ft. above the base. From this point upward to the top the wall is gradually narrowed to a thickness of 15 in. at the top, where a railing of gas pipe is provided. The thin portion of the wall is made of 1:3:5 Portland cement, reinforced on both faces with ½-in. longitudinal bars on 2-ft. centers and ⅝-in. vertical bars on 9¼-in. centers. The remainder of the wall is made of 1:4:6 concrete. The work contains 1,181 cu. yd. of concrete, 22 tons of steel bars, and 225 oak piles, and was placed under contract for a little under $13,000, or $11 per cubic yard.

SURFACE CONDENSER TESTS have been conducted on an elaborate scale by Prof. R. L. Weighton, who read a paper concerning them at a recent meeting of the Institution of Naval Architects. His conclusions were stated substantially as follows: It is conducive to efficiency in a surface condenser that the water resulting from condensation should be intercepted and removed from the condenser as soon as possible after it is formed; also that the condenser capacity should be a minimum consistent with the accommodation of the necessary surface, and that the design should be such as to secure a pervading and uniform flow of vapor throughout the condenser section, thus utilizing the whole of the condensing surface provided, as well as obviating stagnant recesses in which air might be retained; further, that the condensing water should travel at a fairly high speed through the tubes, and that it should enter at the bottom and leave at the top of the condenser. With suitable condenser design and proportions, and in conjunction with dry air pumps, a condensation rate of 20 lb. of steam per square foot of surface per hour will be maintained in association with a vacuum of 28½ in., and a quantity of condensing water equal to 24 times the feed water, at an inlet temperature of 50°. Under the above conditions, and in conjunction with dry air pumps, a condensation rate of 35 lb. of steam per square foot of surface per hour will be maintained in association with a vacuum of 28½ in., and a quantity of condensing water equal to 28 times the feed water, at an inlet temperature of 50°.

REVERSALS OF STRESS in iron and steel have been investigated by Messrs. T. E. Stanton and L. Bairstow, who employed apparatus giving approximately 800 reversals per minute. The experiments were described in detail at the last meeting of the Institution of Civil Engineers, at which time the experimenters summarized their conclusions as follows: 1, The superiority, in resistance to reversals of stress, of moderately high-carbon steels over low-carbon steels and wrought irons, which was discovered by Wöhler to exist when the rate of reversals was 60 per minute, still holds when this rate is increased to 800 per minute, although according to Reynolds and Smith's experiments this superiority no longer exists when the rate of reversals is in the neighborhood of 2,000 per minute. 2, As far as comparisons can be made between the results of the present experiments and those of Wöhler and Sir Benjamin Baker, there is no marked reduction in resistance due to raising the rate of reversals to 800 per minute. 3, Experiments in which the rate of tension to compression varied from 1.4 to 0.72 indicated that between these limits the value of the maximum range of stress was practically independent of the actual values of the limiting stresses in tension and compression. 4, The resistance of the materials in three typical cases of rapid reduction of area of the specimens has been determined. 5, The failure of iron specimens due to the developments of the slip-lines of Ewing and Rosenhain into cracks has been determined for the case of direct stress; and the failure of moderately high-carbon steel, due to the development of cracks in the ferritic areas of the structure has also been established.

Classification of Engineering Expenditures.

By F. H. Newell, Chief Engineer, U. S. Reclamation Service.

In organizing the Reclamation Service the attempt has been made to utilize the results of experience in all similar lines. Various investigations have been carried on into the operations of other engineering organizations to find what has been their experience in apportioning expenditures and in preparing statements of total costs of various classes of work.

Very little information of value has been obtained up to the present time. Most of the large engineering bureaus, State and National, keep relatively few books; their vouchers are audited and a record kept of the totals of these without any notable classification. The apportionment of expenses is left largely to the bookkeeper, and follows some general understanding, which has rarely been put in writing. It has usually been considered sufficient to say that an expense was legal and that the usual charges have been made to the work in hand.

There is also found to be among engineers, especially those in executive positions, a general desire for the introduction of some system of bookkeeping and cost-keeping by which there may be obtained a better knowledge of the relative cost of various features of the work, especially of the administrative and technical items. This desire has not crystallized into any concerted action; but on the contrary each man seems to have a system of his own, or a theory of apportionment of expenditures based upon a somewhat narrow experience along certain lines.

Object.—The object of any classification and distribution of expenditures is to furnish data upon which to direct the work in the future and to furnish proper explanation as to the disposition made of the funds in the past. No classification of expenditures can be successful unless at the outset the object to be attained is had clearly in mind. A large amount of time and money may be wasted in making minute classifications unless these show important facts necessary to the proper conduct of the business. At the outset it is, therefore, necessary to define carefully the classification to be used, and, as experience is had, this classification must be modified from time to time to suit the needs of the administrative head. A system to be valuable must be sufficiently elastic to be readily adjustable to the shifting condition of affairs.

One of the most important objects to be attained is that which relates to the relative expenditures for productive or non-productive work. It is only by continual study of these ratios that intelligent direction can be given.

Productive Work.—The question as to what work or expenditures is productive is a matter which must be carefully considered in each case. In order to have a proper basis for the distribution of expenditures there must be certain definite assumptions made as to what classes of work are productive and what are non-productive. In the case of a machine shop, the productive work is shown by the output of machinery or other commercial articles. The output in an engineering establishment such as the Reclamation Service consists of certain definite structures, each of which may be considered as analogous to the output of an industrial establishment.

Non-Productive Work.—In every commercial work there is necessarily a series of expenses which are classed as non-productive. These embrace general supervision, bookkeeping, inspection, policing, fire protection, etc. In the same way, in the work of the engineer there are many similar non-productive expenditures along lines which are important, but which do not lead to visible output. In the proper conduct of work these non-productive expenses should be separated and carefully studied in connection with the productive expenses.

Methods of Classification.—In addition to the two general classes of productive and non-productive expenditures there is an almost innumerable number of ways or subjects under which the classification of expenses can be made. There are, however, two broad general lines which may be recognized:

(A) Character of the expenditure as regards the functions performed or material received; such as, for services, for traveling expenses, for equipment, for supplies. This is the kind of information which is usually demanded by the public. It is also included in the consideration of productive and non-productive labor.

(B) Objects in detail for which the expenditure is made; or, in other words, the product or output. This is most important from the administrative or technical side as regards cost of various units of production.

Many corporations and public bodies make two entirely distinct classifications based on these principles. The first classification (A), by services, expenses may be regarded as basal or fundamental to all other classifications, since nearly all finished products include these expenditures for services, materials and miscellaneous expenses. These two classes of expenditures (A) and (B), if shown diagrammatically, may be said to lie at right angles to each other. If one is expressed by columns vertically across the page, the other may be given by horizontal lines or figures arranged on these lines. In other words, all expenditures can be arranged vertically and horizontally on a page under the respective headings of each of these two classes (A) and (B).

The basal charges (A) may be considered in an arbitrary order, beginning with salaries, then taking up expendable supplies, then the more permanent articles, and finally ending with the equipment or plant which remains when the work is done. The number of grades or classes may be indefinite, but for practical results it is important to confine these to a few general classes, or at the most ten, as this allows of their being entered in vertical columns on a page of convenient width, or of being modified in a decimal system. On the other hand, the number of classes (B) may be very large.

Geological Survey Classifications.—In the operations of the Geological Survey these two forms of classification have been adopted for all expenditures. Under the first form (A) is the arrangement of expenditures in accordance with the kind of work performed or material acquired. Under the second form (B) is that which conforms to the appropriations, these indicating the objects to be attained. These latter are usually in the form of output or production of maps and reports. Under the first classification there are eighteen distinct schedules of expenditures, these being arranged in two groups, the first including the non-expendable material in eight classes, and the second the expendable material, such as rations and general supplies, also including services, traveling expenses and storage. These schedules are shown in the following list:

Non-Expendable Material.—A, field material, camp supplies; B, instruments used in the field and in offices; C, furniture and removable fixtures; D, books, maps and pamphlets; E, drawing instruments; F, apparatus for photography, etc.; G, apparatus for chemical and physical analyses; H, tools, etc.

Expendable Material, Services, Etc.—I, general supplies and repairs, such as nails, rope, etc.; J, rations or materials purchased for subsistence; K, services, including salaries, wages, etc. (Rec. 1); L, traveling expenses (Rec. 2); M, transportation, including express, freight, etc.; N, illustrations for reports; O, office rent; P, storage and pasturage; Q, correspondence; R, bonded railroads transportation.

Reclamation Service Classification.—In attempting to apply this classification of the character of expenditures to the operations of the Reclamation Act it was found that this did not yield the needed results. For example, the expenditures under many of these schedules are found to be insignificant, while under a few others there are large items which should be further subdivided. The attempt, therefore, has been made to secure an elementary or basal classification which will be more simple and will give totals more in accordance with the requirements of law and the necessities of administration.

Primary Charges.—Items of expenditure under the Reclamation Act are subdivided primarily under the various projects in the different States, these subdivisions being comparable to the principal items of appropriations of the Geological Survey. The primary charges are, for example, Arizona, Salt River project; California, Yuma project, etc. On the same basis with these primary charges are included the Washington office administrative expenses, and the expenses of consulting engineers and other experts, these latter being, however, apportioned from time to time to the different principal projects.

Secondary Charges.—A secondary classification is also made of all of these primary charges, in accordance with the character of the work performed on each of the projects, in order to show in a general way the cost of the larger items of examination, survey, etc. This secondary classification is as follows: (a) examination; (b) survey; (c) design; (d) sub-division; (e) rights and property; (f) construction; (g) maintenance; (h) operation; (i) executive.

These secondary sub-divisions are capable of indefinite expansion, and in actual operation it is expected that they will be further sub-divided to show not merely the steps taken in the work, but also the amounts chargeable to the principal parts of the work. In expanding the secondary classification the judgment of the responsible man in charge should be used. It is possible to expand these to a point where the records are cumbersome, or, on the other hand, leave them in such condensed form that the full value of the results is not had.

Each of these secondary charges may be considered as the proper heading for a page in the general ledger. In sub-dividing or expanding these charges full consideration must be given to the question as to how far the general ledger should be sub-divided, or to what extent these matters should be left for the cost ledger, the latter being intended to expand still further these secondary charges. For example, the term "examination" can be sub-divided into several pages of the general ledger or left for the cost ledger: examination for power canal, examination for principal dam, examination of irrigable land, examination of pumping projects.

In the same way the next item, that of survey, can be expanded into survey of power canal, survey for principal dam, survey of irrigable lands.

The term "construction" affords the widest range for the exercise of judgment as to what may be sub-divided into construction of each of the larger items, or of each of the parts. Here is where it is necessary to exercise the largest discretion as to the extent to which these matters should be entered into in the general ledger or digested in the cost ledger.

To illustrate a moderate degree of expansion of this secondary classification, the following list is given as applicable to the Salt River project:

Examination of general project
“ “ power canal
“ “ principal dam
“ “ irrigable lands
“ “ character of water.
Survey of storage basin
“ “ canyon
“ “ head-works.
“ “ irrigable lands.
Design of power canal dam
“ “ canal
“ “ power plant
“ “ main dam
“ “ head-works.
Subdivision of irrigable land.
Rights and property in storage basin.
Rights and property in valley.
Construction of power canal dam
“ “ power canal
“ “ pressure pipes
“ “ power plant
“ “ main dam
“ “ roads.
Maintenance of power canal
“ “ power plant
“ “ large dam
“ “ irrigation canal.
Operation of power canal
“ “ cement mill
“ “ irrigation canal.
Executive, Phoenix office charges.
Executive, Roosevelt office charges.

Tertiary or basal charges. Each of these primary and secondary charges is capable of being sub-divided into what has been termed tertiary charges, these being the fundamental classifications based upon the character of the expenditure as before described. These tertiary or basal charges are similar to the eighteen schedules of the Geological Survey, but the number is reduced from eighteen to not more than eight, as it is believed that these furnish the principal information desired by the public. These tertiary or basal charges, as originally outlined on the charge sheet of the Reclamation Service are as follows:

1. Services, including all charges for salaries, wages, or hire of men with teams, comparable to Schedule K of the Geological Survey, and to items I and II below.

2. Traveling, including all incidental expenses, comparable to Schedule L of the Geological Survey and included in III below.

3. Subsistence, rations, food and water, meals and lodging when not traveling, including ration list of Geological Survey, or Schedule J and equivalent to III below.

4. Equipment, or purchase of non-expendable property, including animals, wagons, etc., including Geological Survey Schedule A, and equivalent to IV below.

5. Materials, expendable property entering into construction, including freight on same. There is no corresponding Geological Survey schedule, similar articles being included under Schedule I, General Supplies and Repairs. This is equivalent to V below.

6. Supplies, expendable property used in preliminary construction work and wholly consumed therein, such as fuel, explosives, lubricants, stationery, advertising, etc. Equivalent to Schedule I of the Geological Survey, or No. IV below.

7. Rent and storage. Equivalent to Schedule P of the Geological Survey, included in III below.

8. Forage, including all charges for feed and care of animals. Not specifically provided for in Geological Survey schedules.

The above described tertiary or basal charges have in practice been found to be not wholly satisfactory, and it may be desirable in future to combine some of the smaller items and expand some of the larger ones, ultimately making ten basal charges. For example, traveling expense, rent and storage, and forage are found to be relatively small in amount, while the item of services is very large and should be sub-divided into the character of the services.

Tertiary or Basal Charges for Quarterly Estimate.—Since the preparation of the charge sheet it has been found desirable to make a classification of future or proposed expenditures in order that these may be submitted to the department for approval in advance. The character of these proposed expenditures is similar to those above described under the head of tertiary or basal items of the charge sheet. This classification has been used as being most easily recognizable by the auditor or by accountants in passing upon the vouchers or claims submitted. It is arranged in order, beginning with salaries, then subsistence and the more quickly expendable materials, then the less readily expendable, then real property and contracts.

These items of proposed tertiary or basal charges are as follows:

I. Salaries of engineers, experts, clerks, etc. (Schedule K or No. 1 above.)

II. Wages of foremen, mechanics, laborers, etc. (Schedule K, or No. 1 above.)

III. Expenses for subsistence, forage, camp supplies, etc. (Schedule J, or No. 3 above, and including No. 7 above.)

IV. Expendable supplies, fuel, explosives, etc. (Item I, or No. 6 above.)

V. Materials entering into construction, as cement, lumber, etc., or No. 5 above.

VI. Equipment not expendable, machinery, tools, wagons, etc. (Schedule A and I, or No. 4 above.)

VII. Purchase of lands, rights of way, etc. (Not in Geological Survey schedules, nor in tertiary charges above noted.)

VIII. Contracts for construction.

This classification is very similar to that of the tertiary sub-division already adopted, but differs from it in a few important details, as will be noted on comparison.

Use of Numerals.—In the mechanical labor of apportioning expenses it has been found convenient to use numerals instead of writing out each time the full description of the items to which any particular voucher may be apportioned. For example, the phrase "examination for power canal" may be covered by a numeral, such as 720. Such a figure placed upon the back of a voucher, with the corresponding amount opposite, enables quick transcribing and facilitates the work of the bookkeeper. A number of large contracting firms and engineering organizations have gradually adopted the numeral classification, using numbers instead of headings. This practice can easily be carried too far, and the clerks handling the work may do it perfunctorily, or not knowing or caring what the figures signify may make blunders. Hence it has been found necessary in using the numeral system to keep in mind at all times what the numbers signify.

To illustrate the use of numerals in one engineering organization the figures from 1 to 29 were reserved for the details of general expenses; from 30 to 69 for manufacturing plant; from 140 to 159 for the power plant; from 160 to 169 for machine shop, etc. Taking up the machine shop alone, the figure 160 signified labor in the shop; 161 signified supplies; 162 materials for construction; 163, tools, etc.

Decimal System of Classification.—As a further refinement or mechanical aid in recording the classification of expenditures the decimal system has been proposed, for general engineering work, confining the basal or tertiary classification to ten units, and these being arranged from "labor" on one extreme to "real property" on the other about as follows:

0. Salaries for administration, etc.
1. Wages of clerical force.
2. Wages of mechanics.
3. Wages of day laborers.
4. Subsistence and travel.
5. Supplies expendable.
6. Material for construction.
7. Equipment.
8. Real estate, lands, etc.
9. Contracts.

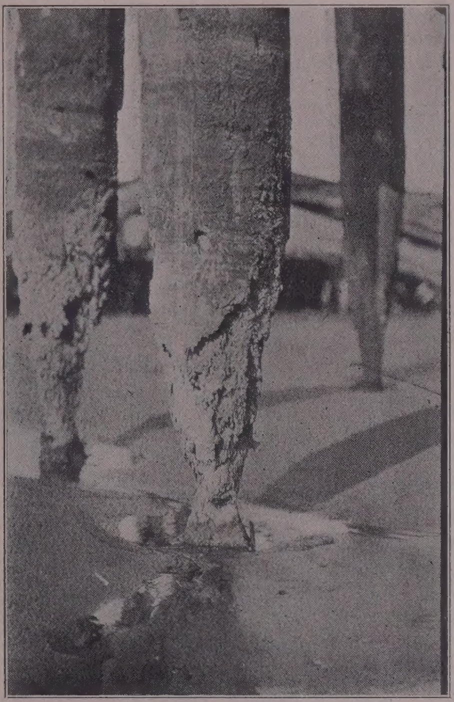
The unit figures should be employed to indicate the basal or tertiary classification. The decimals and hundreds should be reserved for the secondary classification or ledger pages. Applying this to the Salt River Reclamation project, the arrangement would be as follows:

70. Supervising, sand crushing plant.
71. Clerical labor, sand crushing plant.
72. Mechanics, sand crushing plant.
73. Day labor, sand crushing plant.
74. Subsistence and travel, sand crushing plant.
75. Supplies (repairs), sand crushing plant.
76. Material for permanent construction sand crushing plant.
77. Equipment, sand crushing plant.

In other words, the numbers from 70 to 79 can be reserved for expenses connected with the sand-crushing plant; 80 to 89 for the sand quarry; 350 to 359 for cable-ways, etc., and the unit figures can be apportioned to the basal or tertiary charges, following the scheme above outlined, or modifying it in each case to suit the existing conditions. This general idea can only be worked out successfully by trial, and is merely suggestive for further development.

Concrete Piles on the Pacific Coast.

Notes have been published from time to time in this journal concerning the use in Europe of reinforced concrete piles for wharves and similar structures. The accompanying picture, taken at Seattle about ten days ago, is one of a large number of views secured by Mr. Frank B. Gilbreth. Some of the structures on the Oakland water front which Mr. Gilbreth photographed are mere wrecks on account of such destruction. He was informed by engineers engaged in wharf construction that a rough-sawed stick of timber will last about 8 months in Puget Sound, a peeled pile is good for a year, and a pile with the bark on will last 1½ years. A creosoted pile will last from 15 months to 15 years, but unfortunately there is no way of foreseeing which term of life may be assigned.



Timber Piles at Seattle.

While wood piles are cheap on the Pacific coast, they cannot be economical if destroyed frequently, and the utility of the reinforced concrete pile accordingly merits attention. It cannot be used, of course, in structures framed like timber wharves, for wood and concrete have wholly different physical properties. If a wharf is so designed, however, that the concrete is not subjected to sudden shock, which involves merely the use of timber fender piles, so few in number that their renewal is neither expensive nor troublesome, it is difficult to see how the construction can be bettered. Large cylinder piers may be useful in some situations, but the reinforced concrete pile has a wider range of application.

The Pennsylvania Railroad Bridge at Havre de Grace.

The Philadelphia, Baltimore and Washington system of the Pennsylvania R. R. crosses the Susquehanna River between Perryville and Havre de Grace, Md., on a bridge about 4,154 ft. long, and half a mile above the mouth of the river and one-quarter mile below Watsons Island, where the stream is divided by a bar into two channels. The eastern channel has a low-water depth of about 50 ft., and the western channel one of about 25 ft., while on the bar the maximum depth is only about 5 ft. The original structure at this point was a single-track bridge with two lines of wooden Howe trusses reinforced with arches and about 20 ft. apart on centers. It was replaced by a second bridge with an iron superstructure having its axis perpendicular to that of the river and providing a minimum clearance of about 20 ft. above low water. The floor is cambered with a regular curve from abutment to abutment which rises to a maximum height of 27½ ft. above low water at the center of the bridge. This structure, still in use, has a total length of 3,273 ft. 9 in. between abutments, and comprises eight spans of 250 ft. 9 in., and five spans of 174 ft. 9 in. to 253 ft. 6 in.

The spans rest on stone masonry piers with pile or rock foundations. It is notable as one of the longest and most important of the early railroad bridges and was built in accordance with a charter granted by the Maryland legislature in 1853. Surveys were made in the same year, when a little work was done on the superstructure, after which operations were suspended until 1862 when the final location of the piers was decided and pile driving was commenced. Work was continued during the summer and fall of the succeeding years until its completion in 1866.

Part of the piers have pile foundations capped with grillages of four courses of 12x12-in. sawed yellow pine timber. One course is longitudinal, one transverse and the other two are laid as angles of 45 degrees in oposite directions. On the grillages are built the solid masonry piers which were constructed in iron cofferdams riveted and calked and bolted to the grillage platform. The caissons were provided with interior transverse frames and wedges which were adjusted to hold them to the required outlines indicated by exterior wooden templates. They were sunk with fixed vertical guide timbers, some of them being floated and some of them being suspended by vertical screw rods at each corner, which were operated by hand or by steam power with bronze nuts simultaneously turned by worm gear and pinions. In some cases the pile foundation was replaced by rubble masonry carried down to the bed rock and built by divers in riveted iron foundation tanks or open caissons sunk to enclose and protect the sites. In this case a grillage platform, sometimes containing as many as eight courses of timber, was sunk on top of the masonry in the tank and the space between its edges and the walls of the tank was filled with concrete.

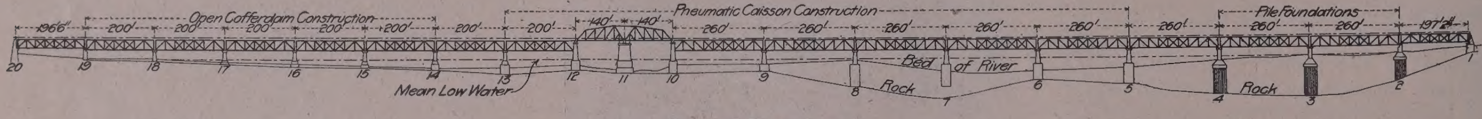
Before the substructure was built the bed of the river was explored by soundings, by test borings and by hand-driven test piles. The borings were made with a 3-in. pod auger 18 in. long, operated by ⅞-in iron rods 12 ft. long coupled together with sockets and set screws and turned by men operating four capstan levers. This apparatus indicated the position of the rock, but was considered worthless for securing samples of the strata. Where the water was more than 25 ft. deep the auger was enclosed in a 4-in. casing pipe to prevent bending and breaking. The result of the boring showed the bottom to consist of alternating strata of mud, sand and gravel in varying thicknesses.

The old bridge was designed for very light locomotives and train loads and having been subjected for many years to a constantly increasing weight and speed of traffic it became eventually inadequate for the present service and will soon be replaced by a new double track steel bridge which is now being built parallel with it and about 150 ft. distant on centers. This structure is designed in accordance with the revised specifications of 1906, which comprise a number of modifications from previous practice on the Pennsylvania R. R. Although they are considered as still subject to minor changes, these specifications now conform to advanced methods of manufacture and traffic conditions and have been developed from the service records of bridges on several thousand miles of main and branch lines during the past fifty years.

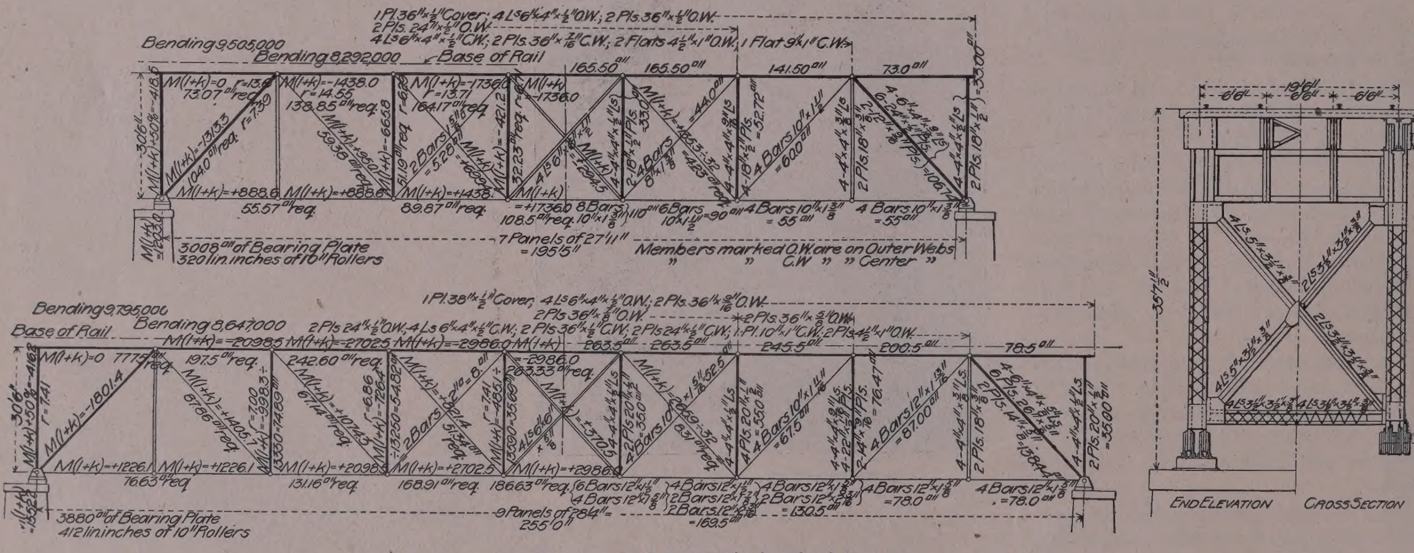
The dead load consists of the steel weight plus the wooden ties and an allowance of 160 lb. per lin. ft. of track for rails, fastenings, etc. The live load consists of a 5,000-lb. per lin. ft. train on each track headed by two consolidated locomotives, each weighing 374,000 lb. on a 107-ft. wheel base. Horizontal wind pressure is assumed to be 30 lb. per square foot on the side elevation of the loaded structure and 50 lb. on the unloaded structure. A pressure of 30 lb. per square foot is also assumed on the side of a train 10 ft. high beginning at 2½ ft. above the base of rail and moving across the bridge. Anchorage for the loaded structure is proportioned for an assumed train load of 800 lb. per lin. ft.

The maximum and minimum calculated compression or tension stresses in any member, due to dead and live loads, are respectively designated as M and m, and their quotient $m \div M = R$. In proportioning members, the stress M is multiplied by a coefficient $(1 + k)$, provided to allow for impact, and the result $M\ (1 + k)$ is considered as the correct stress in the member. The value of the coefficient is obtained from the formula $k = 1 - 2R + R^2$, which, being proportioned in accordance with the dead as well as the live load, recognizes the influence of the mass of the bridge and is believed in extreme cases to give more rational results than the ordinary formulas. In short spans the difference between this result and those obtained by other methods is small. All members are so proportioned that the working unit stresses shall not exceed 16,000 lb. for tension or compression.

The net cross-section of long hip verticals of through spans are 25 per cent. in excess of the specification requirements, and short floorbeam hangers and posts carrying panel loads only have net cross-sections 50 per cent. in excess. When the maximum stress due to wind, momentum of train, vertical load, centrifugal force, and impact exceeds 20,000 lb. per square inch, properly reduced by a compression formula, the cross-section must be increased until this limit is not exceeded. To insure stability under increased live loads a live load is assumed 100 per cent. greater than that above provided for. If the resultant stress, $M\ (1+k)$, in any member is more than twice the permissible unit stress, additions must be made to the cross-section until that limit is not exceeded. Counters with a minimum section of 1½ sq. in. must be provided where required by the increased live load.

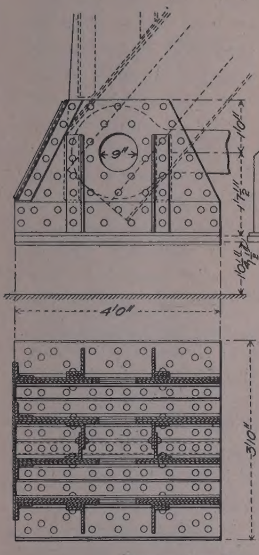


General Elevation.

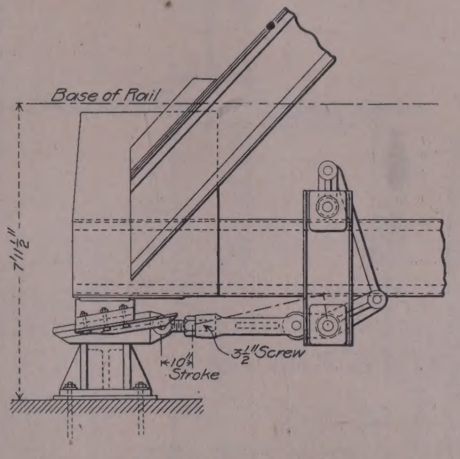

Bending 9,505,000
Bending 8,292,000
Base of Rail
1 Pl. 36"×½" Cover; 4 Ls 6"×4"×½" O.W.; 2 Pls. 36"×½" O.W.
2 Pls. 24"×½" O.W.
4 Ls 6"×4"×½" C.W.; 2 Pls. 36"×7/16" C.W.; 2 Flats 4½"×1" O.W.; 1 Flat 9½×1" C.W.
165.50□"
141.50□"
73.0□"
7 Panels of 27'11" = 195'5"
Members marked O.W. are on Outer Webs
" " C.W. " " Center "
3008□" of Bearing Plate
320 lin. inches of 10" Rollers
Bending 9,795,000
Bending 8,647,000
9 Panels of 28'4" = 255'0"
3880□" of Bearing Plate
412 lin. inches of 10" Rollers
End Elevation
Cross Section

Stresses and Materials in Fixed Spans.

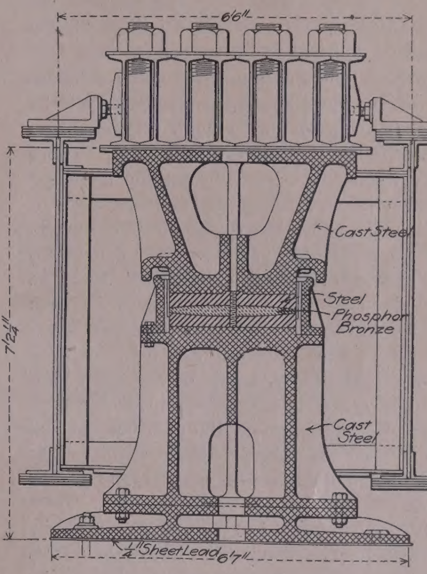
Pins and bolts are proportioned for a maximum bending moment of 25,000 lb. per square inch in extreme fibers, and have a bearing pressure of 24,000 lb. per square inch, which may be increased to 26,000 lb. for rivets. Rivets, bolts and pins have a maximum shearing stress of 12,000 lb. per square inch. In track stringer and floorbeam connections the number of field rivets is increased 33⅓ per cent. more than is required by the above rules. All other field riveted joints require an excess of 25 per cent., if driven by hand, and 10 per cent. if driven by power.



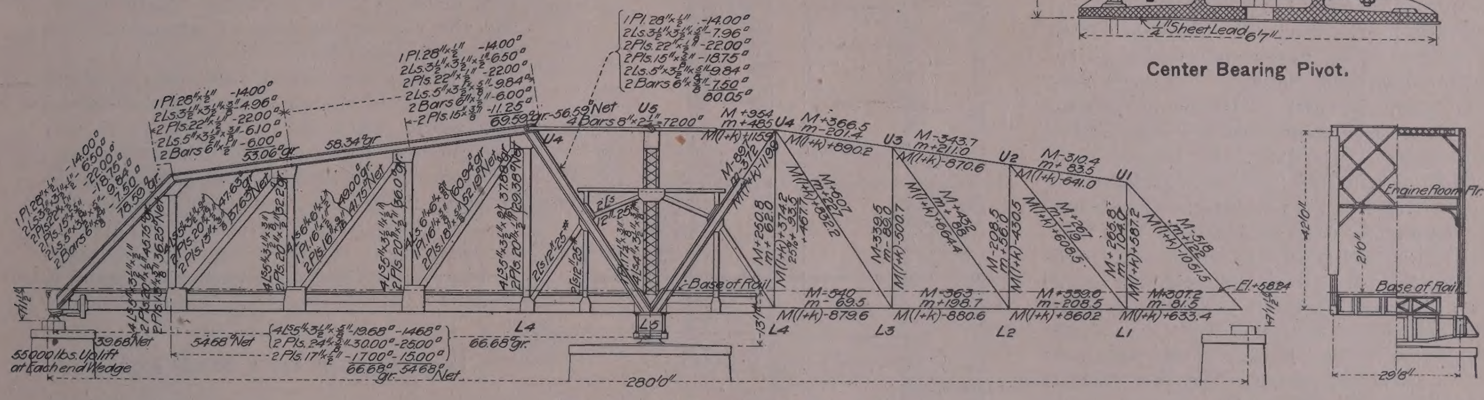
Expansion End Shoe.



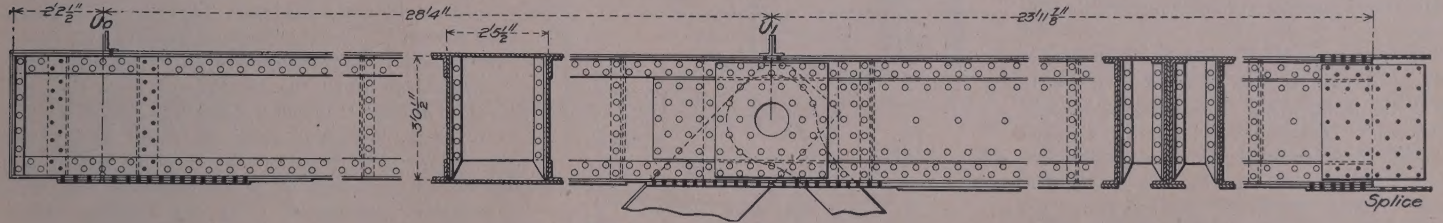
End Lifting Wedge.



Center Bearing Pivot.



Stresses and Materials in Swing Span.



End Section Top Chord.

Rivet holes are punched full size in material up to ⅝ in. thick. In material more than ⅝ in. thick the punched holes are reamed 3-16 in. The ends of all stringers and floorbeams are squared in a facing machine. All field-riveted connections, except those for laterals and sway-braces, are assembled and reamed at the shops or else the field-rivet holes are reamed to an iron template at least 1 in. thick.

All material is soft open hearth steel with an ultimate strength of 52,000 to 60,000 lb., elongation of 25 per cent., and reduction area of 50 per cent. Test pieces must bend cold 180 deg. and close up tight without cracking, and a punched hole ⅞ in. in diameter and 1½ in. from the center to the edge of the piece must be drifted to a diameter 50 per cent. greater than that of the original hole without cracking. Full-size eye-bars must develop an elastic limit of 30,000 lb. and an ultimate strength of 54,000 lb., a minimum elongation of 14 per cent., and an average elongation of 16 per cent.

The superstructure has two lines of pin-connected Pratt trusses 19½ ft. apart on centers. Near the center there is a 280-ft., through-truss swing span, on one side of which there are seven 200-ft. and one 196½-ft. deck spans. On the other side there are eight 260-ft. and one 197-ft. 2-in. deck spans which carry the tracks at an elevation about 30 ft. higher than that on the old bridge.

The substructure consists of masonry piers with concrete hearting. At the sound end of the bridge the abutment and the first six piers had their foundations carried down to bed rock in open cofferdams. The next nine piers were built with pneumatic caisson foundations, all but one of which were carried down to bed rock at a maximum depth of 76 ft. below mean low water. The exception was a pier located where the rock is supposed to be at a depth of about 116 ft. below low water. This pier was sunk about 70 ft. to a solid bearing in a hard gravel stratum. The remaining three piers have foundation piles driven to a maximum depth of 117 ft. and cut off about 30 ft. below low water. They are capped with 1:2:5 concrete footings 8 ft. thick in which they penetrate 2 ft. Above these footings there are six offset courses each 2 ft. high reaching above low water level and supporting the shaft which is made with 20 to 24-in. courses and granite coping. It is provided with a cut-water having an inclined edge protected by an 8x8x⅝-in. angle. The upper parts of the other piers correspond, and their footings, when made of concrete deposited under water, are proportioned 1:2:4. When built in pneumatic caissons they are proportioned 1:2:5.

The pneumatic caissons and cofferdams were built integral up to the river bottom. Beyond that height the cofferdams were made detachable and were removed after the construction of the masonry inside them. The pier having the deepest foundation sustains a combined dead and live load of 4,340,000 lb., which, together with the weight of the masonry, diminished by the displacement, gives a net load of 8,840,000 lb., or 16.2 tons per pile.

The equation of the cost of the superstructure with that of the substructure might have resulted in the adoption of somewhat longer spans. The great irregularity of the bottom would, however, have prevented an economical uniformity of spans, and since the bridge is designed for heavy traffic and high speeds the alternation of long and short spans would be very objectionable for smooth running. It was therefore decided to adopt a uniform length of moderate span, and it is believed that the regularity of members and duplication of parts thus effected has produced a cost little in excess of the theoretical minimum obtained by the use of longer spans. The trusses and floor system have sufficient mass to absorb impact and vibrations and are heavy enough to permit some future increase in loading. They are designed to secure effective disposition of material and the details are noticeably simple, affording direct connections, conforming to standard bridge-shop methods and plant, and eliminating secondary stresses in a large degree. This last feature is especially promoted by the use of a single system of trussing, which avoids intermediate floorbeams, and, with a maximum panel length of 28⅓ ft., provides open panels which are considered very attractive and satisfactory by the engineers of the structure and by others who rank it high among well-designed railroad bridges.

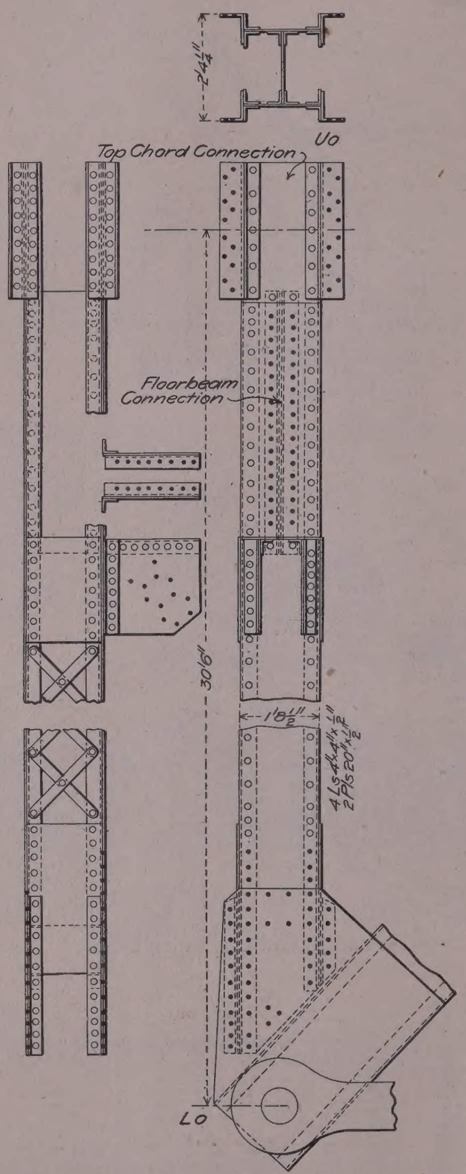
The principal details, materials and maximum stresses of the different spans are indicated by the accompanying diagrams, and the members correspond to the typical details shown. Those in all the fixed spans are substantially alike except in variations of dimensions and in weight of material. The panel lengths are approximately alike in all the fixed spans and the floorbeams are all made with a 60x½-in. web, two 6x6x½-in. angles and one 14x⅝-in. cover plate in each flange. They have 36 field driven connection rivets at each end. The stringers are made with a 37x½-in. web plate and a pair of 6x6x⅝-in. angles and one 14x⅝-in. cover plate in each flange. They have web stiffeners at the end, but none at intermediate points. Each 255-ft. span weighs 1,400,000 lb., and each 195½-ft. span weighs 840,000 lb.

The top chord of the 255-ft. span is 36 in. deep and 38 in. wide and has three webs. It is built up with 6x4-in. angles and is stiffened by vertical transverse diaphragms. The end sections are continuous past the U_1 pins to the center line of the pier where there is a small clearance between adjacent spans. At the piers each top chord is supported by an independent vertical post riveted between its webs. These posts have a rectangular cross section made with four 4x½-in. angles and two 20x½-in. plates. At the lower end they are riveted through their main angles and special angles to projections of the web of the inclined end posts which form jaws receiving them. The floorbeams are web-connected to them and are also seated on double-web knee-brace brackets which serve for connections of the sway brace diagonals through which all lateral stresses are transmitted directly to the shoes.

The intermediate vertical posts are each made with a pair of built channels having their webs parallel to the bridge axis. The posts L_1 U_1 are pin-connected at the lower ends and are riveted at the upper ends to side jaw plates made by extensions of the web in the inclined end posts. All other vertical posts are pin-connected at both ends. All trusses are made with an odd number of panels and the center panel diagonals are riveted members without adjustments. Each of them is made with two pairs of angles back to back, latticed, and was field riveted between jaws formed by plates extended from the adjacent vertical posts.

The end lower chord pins take bearing in shoes which have four webs each. The outer webs are stiffened by heavy vertical angles and the inner webs are connected by a pair of vertical transverse diaphragms each made with a pair of angles having their outstanding flanges riveted together. At the expansion end the shoe is seated on a nest of eight 10-in. segmental rollers with flat sides. The rollers are seated on a 1½-in. bed plate with 4x1-3/16 in. longitudinal bearing strips riveted to the upper surface. At the fixed end the shoe is seated on an unplaned bed plate 1½-in. thick.

The swing span is made with riveted connections at all panel points excepting at the upper ends of the hip joints nearest the pivot where there are pin connections through the horizontal eye-bars across the pivot pier. This span is provided with a center bearing and with eight single reaction wheels engaging a track integral with the full circle turning rack. When under railroad traffic the span is supported on reaction wedges at the ends of the lower chords and under each truss on the transverse center line of the span. All of these wedges are operated with toggles driven by crank shafts and gears from the center of the bridge. An 80-h.-p. gasoline engine, manufactured by Fairbanks, Morse & Co., is installed to operate the lifting wedges and the swinging gear, and is capable of opening or closing the bridge in 80 seconds. Capstan heads and long levers are provided for operating the mechanism by hand in case of any failure of the power.



Pier Post.

The span is supported at the pivot pier through a pair of floor beams with their upper flanges reacting against the lower chords of the main truss. They are 6½ ft. apart on centers and are connected at each extremity by three vertical longitudinal diaphragms symmetrical with the center of the lower chord which provides reactions for the pier wedges. At the center the twin floorbeams are web connected by two double-web vertical longitudinal diaphragms 6½ ft. apart on centers. Four vertical screws 5½ in. in diameter pass between each pair of webs and between four pairs of horizontal longitudinal I-beams 24 in. deep. Their lower nuts engage the botom flanges of the twin diaphragms and the upper nuts engage the top flanges of the I-beams. The centers of the I-beams take bearing on the upper surface of the top pivot casting, thus affording a support for the suspension of the span through the center girders and vertical bolts.

The pivot is of the Edgemore type and is built up with several steel castings. Between the two principal castings there are two loose discs of polished hardened steel separated by a double convex disc of polished phosphor bronze 28 in. in diameter. These discs are enclosed by a cylindrical sleeve-like casting with an annular space for oil in which they are submerged. Both upper and lower pivot castings are made hollow and are stiffened with heavy radial flanges. The lower casting has a horizontal flange seated on an extended base 6½ ft. in diameter with a ¼-in. sheet lead packing on the masonry. The total height of the pivot from the top of the masonry to the top of the upper casting is 7 ft. 2¾ in., the mechanism being thus almost wholly enclosed in the depth of the floor beam girders.

When closed to navigation the bridge is locked into position by a vertical latch bolt 12 in. wide which is operated by a crank shaft. The lower end of the bolt is provided with a friction roller that engages an adjustable recess in a heavy shoe. The bridge is fitted with automatic signals and the mechanism is protected by electric automatic interlocking devices, which make it impossible to open the draw unless the danger signals are set, and also regulate the different movements so as to prevent conflict between them.

Preliminary construction work was commenced in 1903 and the erection of the superstructure is now nearly completed. It contains in all over 10,000 tons of steel, and its design and construction have been directed by the engineering department of the Pennsylvania R. R. Messrs. McMullen & MacDermott were the contractors for the substructure and the contract for the superstructure was divided between the American Bridge Co. and the Pennsylvania Steel Company.

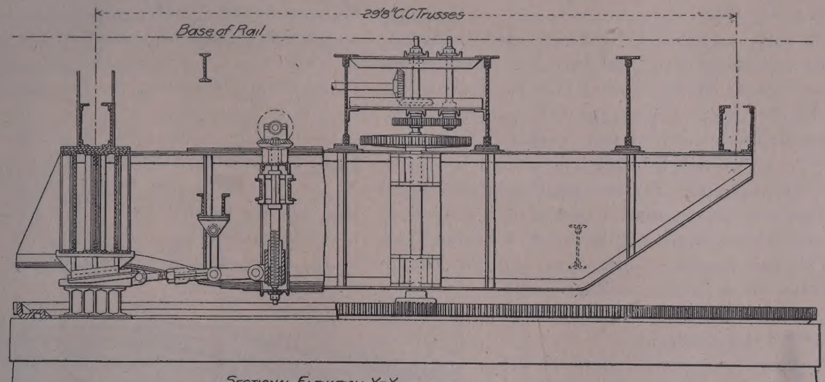
Concrete Roof for a Stock House.

The new stock house of the National Mills of the Alpha Portland Cement Co. will be 387 ft. long, 98 ft. wide and 33 ft. high from the floor to the eaves. It will have no windows, all light being admitted through the roof, and the walls are designed to resist the pressure of loose cement stored against them up to their top. These walls are 12 in. thick and reinforced with steel rods and expanded metal of No. 4 gauge and 6-in. mesh. At intervals of 10 ft. reinforced concrete buttresses are placed along the exterior face. Owing to the absence of inflammable material in the building it was at first proposed to use a roof of sheathing on steel trusses, with a slag finish. Just before the contract was signed with Merritt & Co. for its construction, such a roof on another stockhouse belonging to the company caught fire and was considerably injured, and the cement stored in the building was damaged by the water used in extinguishing the flames. It has accordingly been determined to roof the new stockhouse with slabs of cinder concrete reinforced with expanded metal and covered with an ordinary slag finish.

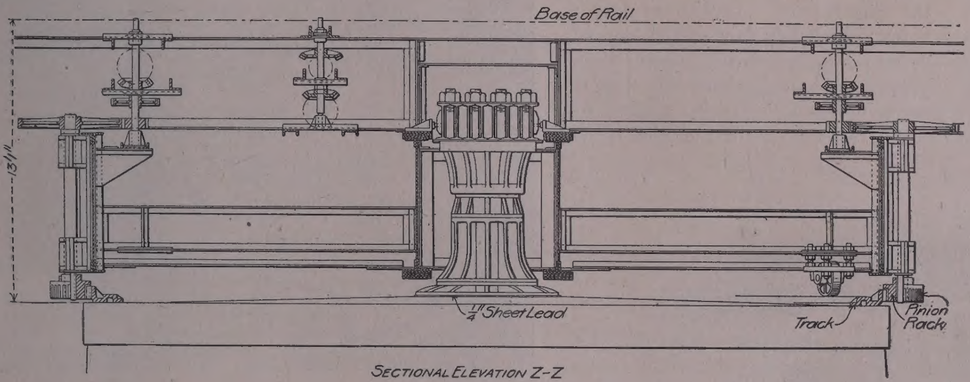
Alcohol Engines to the number of five thousand or more are now in use in Germany, particularly on farms and for running small shops doing light work.

The San Francisco Disaster.

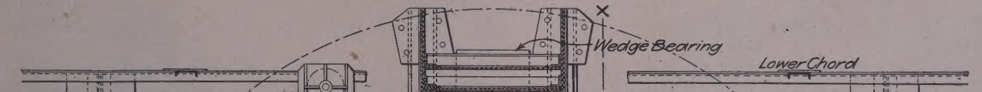
While it is still impossible to give any really definite statement concerning the effect in detail of the earthquake of last week on the well-built structures of San Francisco, enough information has been received concerning the conditions in the afflicted city to show that last week's provisional opinion was justified. Before stating the substance of the reports, however, The Engineering Record wishes to acknowledge the courtesy of its friends in the city and vicinity who have furnished voluntarily such statements of the conditions as they were able to send. Owing to the strict rules of martial law, it has been impossible to have thorough examinations made of the important buildings up to the present time by representatives of this journal, but from men engaged in rescue and salvage work, who were able to see some of the results of fire and earthquake, sufficient information has been gathered to show that high-grade masonry and steel-cage construction has offered successful resistance to both these destructive agents.



Sectional Elevation X-X



Sectional Elevation Z-Z



Swinging Gear and Support on Pivot Pier, Pennsylvania Railroad Bridge.

The earthquake shocks began shortly after five o'clock on the morning of April 18. The first one was severe and was succeeded three hours later by another bad one. Others followed at longer intervals. As a result a number of flimsy buildings were thrown down and in structures of a better class the chimneys were so badly injured that within a quarter of an hour or so fire broke out in many places. This happened not only in San Francisco, but throughout an extensive territory.

The center of the disturbance seems to have been near San José, and the area mainly affected comprised the coast counties of Central California. In San José, 50 miles south of San Francisco, the business section was wrecked and a number of lives lost. At an insane asylum a few miles from the city, over a hundred patients were probably killed by the falling buildings. No damage was done to the buildings or instruments of Lick Observatory, however, which indicates that the flimsy construction of the fallen buildings in the vicinity was responsible for their destruction.

At Santa Cruz, 121 miles south of San Francisco, a court house and several large buildings were destroyed in addition to other damage, but no lives were lost. In the country between San José and Santa Cruz, the disturbance of the terrain was very great, and it is probable that the railways and roads have suffered considerably. In Santa Rosa and the towns in the Sonoma valley, 50 miles north of San Francisco, the damage and loss of life were heavy. Although the earthquake caused much destruction throughout this large district, there were some places within it which escaped serious trouble. At Oakland, for example, about six miles from San Francisco, the injury to buildings was comparatively small, and at Berkeley, five miles from Oakland, the buildings of the University of California escaped without any apparent damage, although a few residence and business buildings were destroyed, and many chimneys shaken down and similar damage done. Leland Stanford, Jr., University, 34 miles south of San Francisco, was greatly damaged by the earthquake, two men were killed, and a number injured. The buildings wrecked are the memorial church, new library, gymnasium, memorial arch and power house. Some of the shops and many of the buildings of the outer quadrangle were seriously damaged. The chemistry building, Encina Hall and the inner quadrangle are practically uninjured.

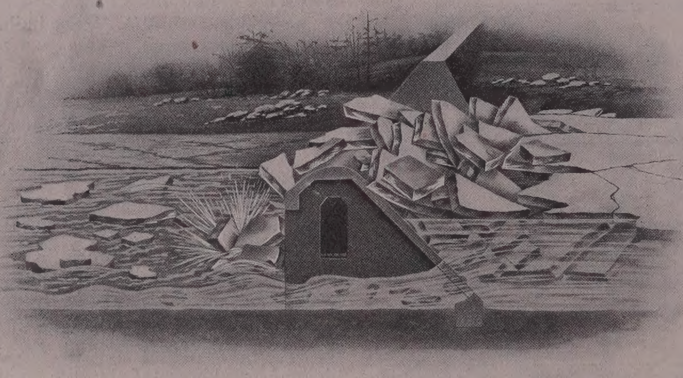
The effects of the earthquake in San Francisco cannot be definitely stated because they are hidden or obliterated by the ruins of the fire which subsequently swept over a sixth of its total area or about three-sevenths of its occupied area. The sensation of the people in the hotels has been generally likened by them to the pitching of a vessel in a heavy sea. Numerous people in the Palace Hotel, for example, an old but well-built masonry structure, have stated that the building swayed enough to roll them out of bed, although it may be questioned whether this is not an exaggeration, for other people sleeping at the time had to be wakened in order to get them up. In this hotel, ceilings were damaged and other injury was wrought, but it seemed for some hours that the guests would not have to leave, a hope that was destroyed by the progress of the conflagration that followed the earthquake.

The terrain of the city was much disturbed, particularly in a low section toward the water front. As is usual in severe earthquakes, there were places where sinking occurred, probably several feet at some points, and small fissures opened, only to close again slowly. This disturbance of the earth wrecked the water mains in a considerable portion of the city and made it impossible, except along the water front, to fight the fires that sprang up in many places within a few minutes of the first shock. An attempt was made to check the general conflagration that ensued by blowing up buildings so as to form fire gaps, but this heroic remedy proved fruitless, and the fire practically had its own way in most sections of the city.

This is a point to which the attention of European readers is particularly drawn, because the

San Francisco disaster was essentially one by fire and not by earthquake. For this reason the fire-resisting condition of the city deserves attention, for it was wholly unlike that of a European place of the same size. It had exceptionally large areas closely covered with buildings of a highly combustible character, and there was a general absence of wide streets or other good fire breaks, so that the potential fire hazard was very severe. There were very few sprinklers or modern fire protective devices, and this condition, coupled with the prevalent high winds and comparatively narrow streets, made the underwriters consider the probability of a serious conflagration as "alarmingly severe." In a recent report by the Committee of Twenty of the National Board of Fire Underwriters, the following significant statement appears: "San Francisco has violated all underwriting traditions and precedent by not burning up. That it has not done so is largely due to the vigilance of the fire department, which cannot be relied upon indefinitely to stave off the inevitable." That statement was made only six months ago.

Although the city was fire swept, many of the large buildings are in good condition. The famous Spreckles building, often referred to as the Call building, was pretty well burned out below, but it is believed that the steel skeleton, which was described in this journal some years ago, in uninjured and parts of the walls and upper floors will need only a thorough cleaning to make them as good as ever. The new Flood Building is but little injured, and the same is true of the Post Office and Mint. In the Mills, Shreve and Merchants' Exchange Buildings the floors are pretty well wrecked, but it seems probable that the steelwork and walls are sound. The damage in the Haywards Building is somewhat less. The Crocker Building is apparently so little damaged that a few weeks' work will make it fit for use again, although its walls were injured more than those of the Mills Building, where the interior damage was greater. The top floor of the Hobart Building seems to present one of the few cases of wreckage due to the earthquake, for the fire injury was so slight that the building could be used again after a few hours of cleaning; it is hardly possible to account for the condition of the top floor except by the shaking during the shocks. The Hibernia Savings Bank was mainly injured on the ground floor. The residence district called Nob Hill, Chinatown and some other well-known sections of the city are wiped out, except for an occasional building here and there, and a large part of the homes of the poorer classes are destroyed. The damage is by no means complete, however, for there are many homes in the city still intact and others that can be restored easily. The great loss is in the destruction of small buildings and business stocks in the wholesale and retail business districts.



Sketch of Ice Action at Westfield River Dam.

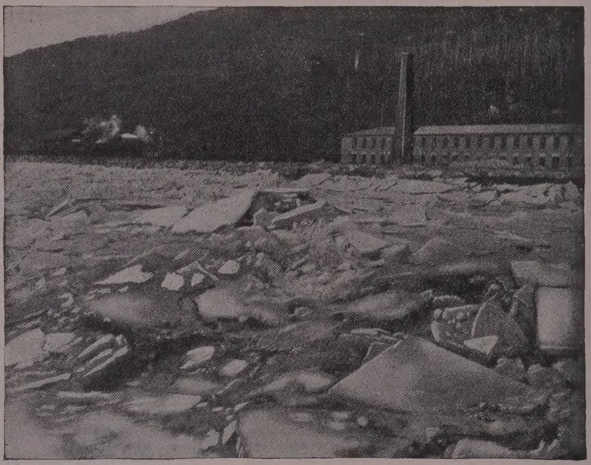
A Dry Test of a Dam.

The Otis Fibre Board Co. is constructing a concrete-steel dam from 15 to 20 ft. high across the Westfield River, at Russell, Mass. The work has been carried on through the winter, but is not quite completed. During the break-up of the river in the first week in March the dam was subjected to an ice stress so peculiar as to warrant description.

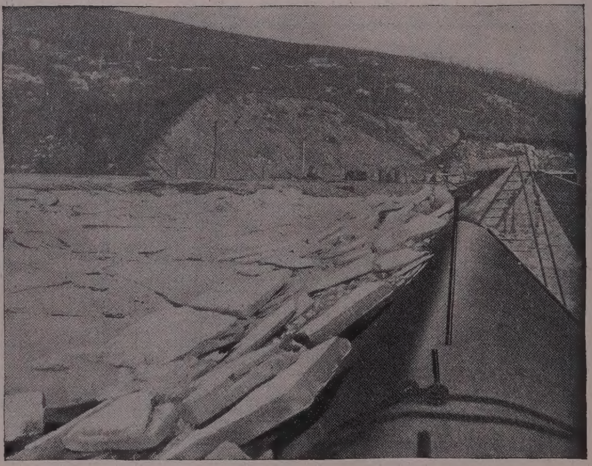
The slope of the deck is 1 on 1, the thickness at the top being 9 in. and at the bottom 12 in. The thickness of the crest is 18 in. The material in the deck is 1:2:4 gravel concrete. The buttresses are spaced on 10-ft. centers. The dam stands on a solid ledge, but it is not anchored in any way, depending for its stability against sliding solely on the roughness of the rock combined with the high angle of the resultant pressures due to the weight of the dam and the water pressure on it. The resultant angle when the dam is just full is about 30 deg. with the vertical.

The general cross section of the dam is fairly illustrated in one of the illustrations. Temporary waste gates were left in four of the bays to carry the water during construction. A mile and a half above this dam is another dam followed by a series of dams for many miles up the river, each creating a pond of moderate extent. The Westfield River is notoriously quick, and a warm rain the first week in March broke up the river throughout its length. The ice in the numerous ponds passed over the several dams comfortably, but when the basin formed by the Otis dam was reached there was not water sufficient to float the ice and the entire basin for a mile and a half became packed with the accumulated ice from the whole river above which lodged against it. The river slowly arose, as the waste gates were insufficient to carry the flow, until the true water level was about half way up the deck of the dam. Under these conditions the pond would extend back but a few hundred feet. At that point the pressure of the ice urged by the quick water above the pond became so great as to force the accumulation of ice over the dam as shown in the illustration. Hundreds of thousands of tons of ice from 12 to 15 in. thick was pushed over the crest of the dam while the water flowed through the gates beneath. The concrete was so hard and the slope so easy that after the ice subsided not even a scratch was to be discovered on the deck or crest. The probability is that an ordinary solid dam having a vertical upstream face would have given away under the enormous strain of a dry test such as this, as there was no water to float the ice over the crest. Unfortunately the heaviest part of the ice shove took place in the evening and before morning the river had commenced to recede. Two or three days later the photographs were taken, during which time the river had gone down to near its normal level and the ice had slipped back on the dam. One of the illustrations shows the crest of the dam a few days after the ice gorge and another gives some idea of the accumulation of ice in the basin above the dam, it being 10 to 15 ft. deep and resting for the most part on the bottom of the river.

During the same thaw a similar dam 28 ft. high, for the Cairo Electric Light Co., at Cairo, N. Y., was subjected to the same character of test, the ice in that case being heavier, but not as great in quantity. Unfortunately photographs of the Cairo dam were not available.



Accumulation of Ice above Dam.



Crest of Dam after the Gorge.

Gas Engine Exhaust has been used for raising steam for several years in Great Britain. In one case, where large engines are employed, the gases are used in tubular boilers specially arranged to utilize their heat very fully, and as a result 70 tons of steam coal are said to be saved. This installation was made by Andrew Barclay, Sons & Co., Ltd., of Kilmarnock, who give some notes in the Engineering Supplement of the London "Times" concerning other installations of the same nature. Tank-measured evaporation tests of boilers using the exhaust from gas engines of an electric plant gave 3.8 lb. of steam at 40 lb. per kilowatt-hour, or 2½ lb. per horse-power-hour. Boilers have been supplied for such purposes which are furnishing steam at 130 lb. pressure. All told, over 5,000 h.-p. of boilers fired in this way have been furnished.

The Surface Finish of Concrete Bridge Masonry.

By George S. Webster, Chief Engineer, Bureau of Surveys, Philadelphia.

In the construction of concrete bridge masonry in Philadelphia the process used for finishing the surface consists merely in removing the face forms while the concrete is still friable and washing the surface with water. To secure a uniform color and complete flushing of the exposed faces, a so-called granolithic mixture is applied to the form in a nominal thickness of 1 in., just ahead of the body concrete, which is placed against and rammed into it, thus securing a perfect bond between the face and the body. This granolithic mixture is a fine concrete composed of one part cement, two parts sand, and three parts granolithic grit.. A very satisfactory color and texture is obtained by using Jersey bank sand, which is bright yellow in color, varying in size of particles from very fine up to pebbles ½ in. in diameter, with crushed-stone grit dark in color with a slaty fracture, screened free from dust and varying in size from ⅛ to ½ in.

The tint of the finished surface depends upon the colors of the sand and the grit, both of which are exposed by the washing. Crushed granite grit with bar sand makes a very handsome surface. Grit composed entirely of pebbles screened from yellow bank sand or gravel gives a warm tint.

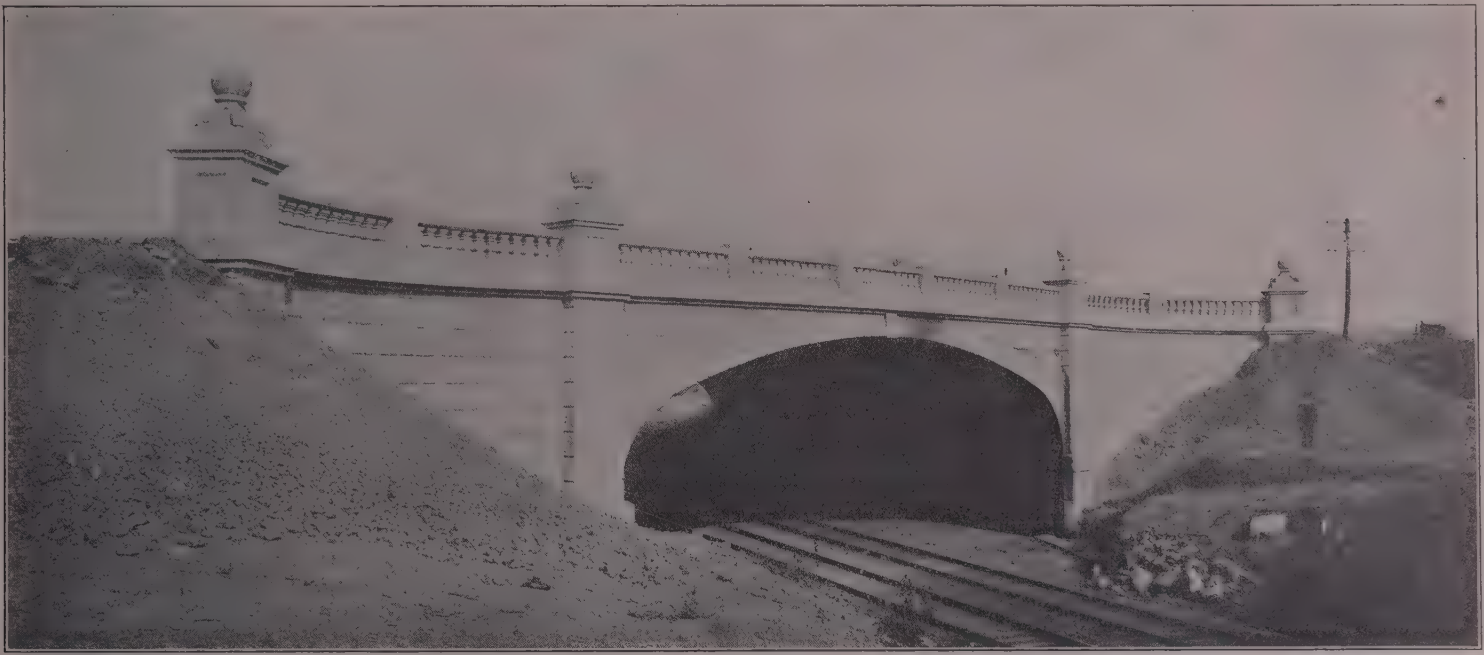
To make the surface accessible for washing at the proper time the face forms must be constructed so that the planks can be removed without disturbing the uprights, unless the job should be small enough to deposit all the concrete in one day, for in warm weather the material sets so fast that the washing should be done within 24 hours of depositing. This is accomplished by setting the uprights 6 or 8 in. away from the face of the concrete and securing the planks with tacked cleats and wedges against the uprights, only enough plank for one day's work of depositing being required, the planks used for one course being shifted up the next day to receive the next course.

The washing of the face should be done as soon as the plank is removed, because the surface hardens rapidly when exposed to the air. When it is reached at the proper time only a few rubs of an ordinary house scrubbing brush, with water flowing over it from a sponge or bucket, or preferably a hose, will be sufficient to remove the cement film and expose the sand and grit of the granolithic face mixture. If blemishes appear on the removal of the planks they can be patched neatly because of the freshness of the material; voids can be filled with the same mixture, and bulgings or offsets can be rubbed off with little labor and without changing the appearance. No subsequent treatment is needed unless the face be soiled by cement water from the upper courses or other dirt, when, of course, it should be washed and rinsed off again.

The coarser the grit used in the face the rougher the surface, and, in the opinion of most observers, the more pleasing the effect. In a rough surface little irregularities are not noticeable, and joints between courses or between different days' work in the same course can be made so as to be scarcely distinguishable. In order, however, to avoid the necessity of extra care to conceal the joints between courses it is our practice to use heavy triangular beads to leave an imprint along each joint, finishing a course at the apex of the bead, and the effect of these imprints on the architectural appearance is pleasing because the monotony of what might resemble a plastered surface is thus broken up.

In cold weather the face plank cannot be removed so soon, two days probably being required for the concrete to attain sufficient strength, and one week in the form has been found to be not too long to permit easy washing.

If the concrete has been permitted to set too hard for washing with a brush, rubbing with a piece of wood or brick will cut the film if plenty of water be used during the rubbing. If the face has become so hard that rubbing is too laborious, a very satisfactory surface can be obtained by bush hammering, which produces an effect somewhat similar to that of washing, though the sand and grit are not so well cleaned nor so completely exposed.



Boulevard Bridge over North Penn Railroad, Philadelphia. Reinforced Concrete, 69 Ft. span.

THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA has moved into new quarters in the Fulton Building, on Sixth St., Pittsburg. The rooms include an auditorium, reception room, reading room and library, office and directors' room. It is proposed to make the club the city's engineering headquarters.

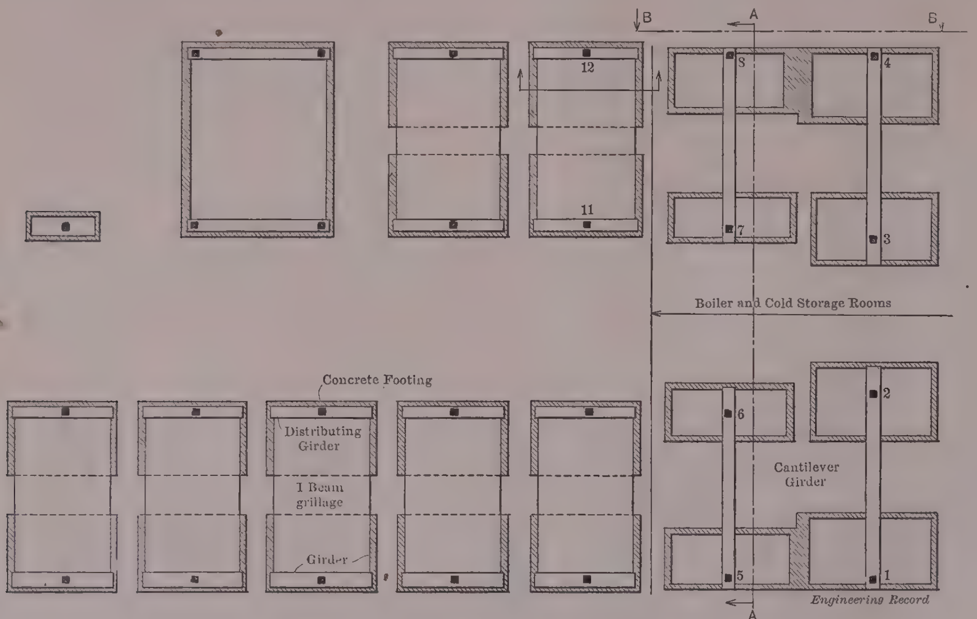
The Steel Foundations of the Title Guarantee & Trust Co. Building, New York.

The 135x75-ft. steel cage office building at 176 Broadway, New York, for the Title Guarantee & Trust Co., has a nominal height of six stories above the street, but including the mezzanine and basement stories there are twelve floors. These with the walls and roof are supported on a very simple system of longitudinal and transverse I-beams and plate girders carried by 27 main columns from 18 to 22 ft. apart in four longitudinal rows about 22 ft. and 25 ft. apart. The columns have closed rectangular cross-sections made of two channels and two cover plates, and in all cases have base plates extending the area only a few inches on opposite sides and seated on distributing girders. These girders transmit the loads to grillages of I-beams proportioned to reduce the unit pressure to safe limits for the fine wet sand on which they are seated with concrete footings.

Down to about ground-water level, the general excavation was made by hand with ordinary methods inside wooden sheet piles, which retained the earth at the ends of the lot, the sides being bounded by the walls and foundations of adjacent buildings carried down to about the same depth as the main cellar of the new building. Below the water level special methods were adopted for making the grillage excavations without disturbing the equilibrium of sub-surface or undermining the adjacent foundations, as described in The Engineering Record of March 3, 1906. The cellar is divided by a transverse line into two unequal portions. The larger one, in the rear, has a length of about 91 ft., and was excavated under the grillages to a depth of about 25 ft., being about 1 ft. below ground-water level. The other portion, which extends under the Broadway sidewalk, has a length of about 47 ft. over all and is carried down nearly 7 ft. deeper to provide more space for a boiler room and vaults.

In both sections of the cellar the grillage beams are laid with their upper flanges about 2 in. below the finished floor surface, and their combined areas occupy more than half of the total area of the building. They are arranged as indicated in the plan in groups supported on concrete footings carried down in the upper part of the cellar to a depth of 12 in. below their bottom flanges. In the lower part of the cellar these depths are increased by different amounts, as shown in the longitudinal section.

All of the grillages at the lower level and the largest one at the upper level have single concrete footings extending continuously over their entire area. Each of the remaining grillages is seated on two solid footings, one at each end, which concentrate the loads on the soil so as to provide uniform unit pressures there and thus insure equality and regularity in any settlement which may occur from the live and dead loads of the structure. As the column loads and their application to the grillages vary, the sizes of the footings are correspondingly varied, but all of them are simple rectangles enclosing the grillages from a little beyond one end to a point near the center. The separate footings range from 7 ft. 3 in. by 15 ft. 6 in. to 12 x 16 ft. for those in pairs, while the large single footing is about 26 ft. 3 in. by 22 ft. 9 in. over all. An exception to the regular arrangement is a single wall column at the rear end of the building which has a light load and is carried without a distributing girder on three grillage beams with a long and narrow footing.

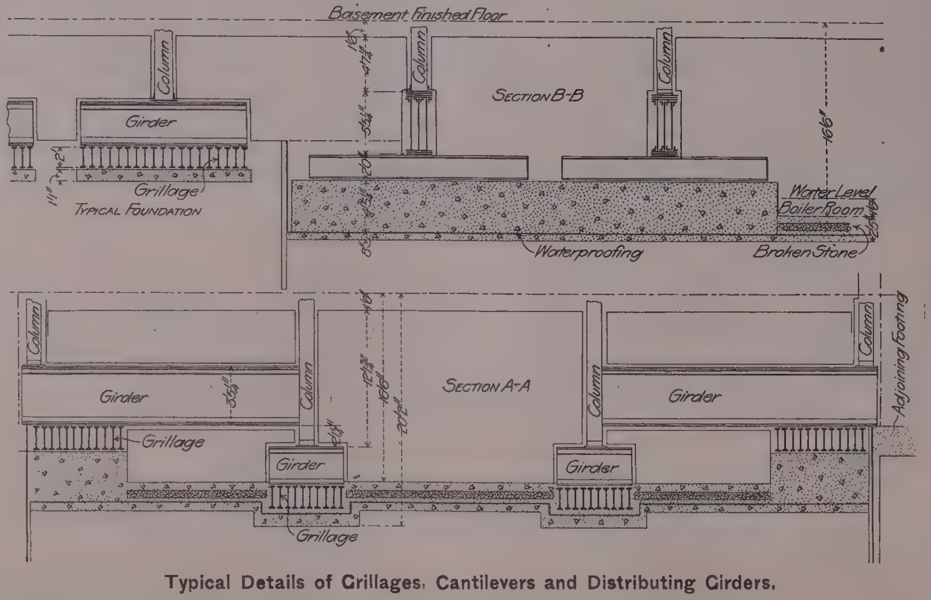


Plan of Foundations, Title Guarantee and Trust Co. Building, New York.

In the depressed part of the foundations, the pair of grillages adjacent to each side wall of the building are carried on a single long continuous footing. The four interior grillages in this part have their single footings separated by spaces only a few inches wide. The two grillages at the rear of the lot are made of 18-in., 55-lb. I-beams; the remainder of the grillages are all made of 24-in., 80-lb. I-beams arranged in groups of 10 to 29 and are from 18 to 27 ft. in length. Great care was taken to set the I-beams to exact elevation, and to this end they were seated on narrow transverse strips of accurately leveled concrete, one at each end, which raised them 1½ in. above the surface of the footing. When thus perfectly adjusted they were surrounded with grout to a height of 2 in. above the footing, and the spaces between their webs and around their ends and exterior surfaces were carefully concreted.

In most cases the grillage beams act as cantilevers with concentrated loads very near their extremities and long continuous supports which have their centers of gravity between the column centers. This provides symmetrical loading for the footings and still permits the wall columns to be carried over the outer edges of the latter, and in one case, where the outer walls make a re-entrant angle, a group of three wall columns and one interior column balance each other at the three corners of the large single grillage footing.

The column loads are distributed across the upper flanges of the grillage beams by double and triple-web plate girders from 42 to 60 in. in depth. The largest is about 30 ft. long, weighs about 16 tons and is made of four 6x6⅞-in., and four 6x4x7/16-in. angles, and four 24x⅞-in. cover plates in the flanges and with three 60x¾-in. web plates reinforced by four 58x⅜-in. plates. This girder, like the parallel ones shown in elevation in the transverse section of the boiler room, are supported at one end directly on the top flanges of the grillage beams in the wall footings, which are raised about 5 ft. above the cellar floor by building up the concrete footings to serve as solid piers 5½ ft. deep. At the other end it is web-connected to the column and the latter is carried down farther to rest on the ordinary transverse girders with its bearing on grillage beams below the floor level. In other respects the regular distributing girders correspond to those shown for the columns in the rear part of the building.



Typical Details of Grillages, Cantilevers and Distributing Girders.

The total weight of the grillage beams and girders is about 900,000 lb., and the total weight of all the structural steel in the building including the foundations is about 3,400,000 lb. The estimated total weight of the building and contents is about 40,000,000 lb., and the pressure per square foot on the surface of the soil is about 8,000 lb. The maximum column load is 1,676,000 lb., and 1 in. final settlement of the building is thought likely to be the maximum; but as an additional four stories of superstructure which are provided for have not been built, no settlement whatever has yet been detected.

As the grillage beams in the depressed part of the foundations are several feet below groundwater level, special pains were taken to protect them from moisture and corrosion. The entire cellar floor and the walls up to an elevation considerably above ground water line were covered with five and seven-ply tar and felt, and where the excavations for the grillages were made in sections as explained in the article printed on March 3. After each section of floor concrete was waterproofed, a full-size copper pan was seated on the water-proofing and a second layer of water-proofing was put in the pan over the grillages. Afterwards when the adjacent sections of excavation were completed and the floor concrete was brought up to the level of the lower layer of waterproofing, its surface was correspondingly waterproofed, and the vertical sides of the copper pans and interior flashed waterproofing were flattened down horizontal on the new surface and the upper layers of waterproofing were spread continuously over them, making wide lap joints which were enclosed in the upper part of the concrete.

Messrs. Howells & Stokes are the architects of the building. The Thompson-Starrett Co. is the general contractor, and the structural steel work was furnished by the American Bridge Co.

A Gasoline-Electric Car.

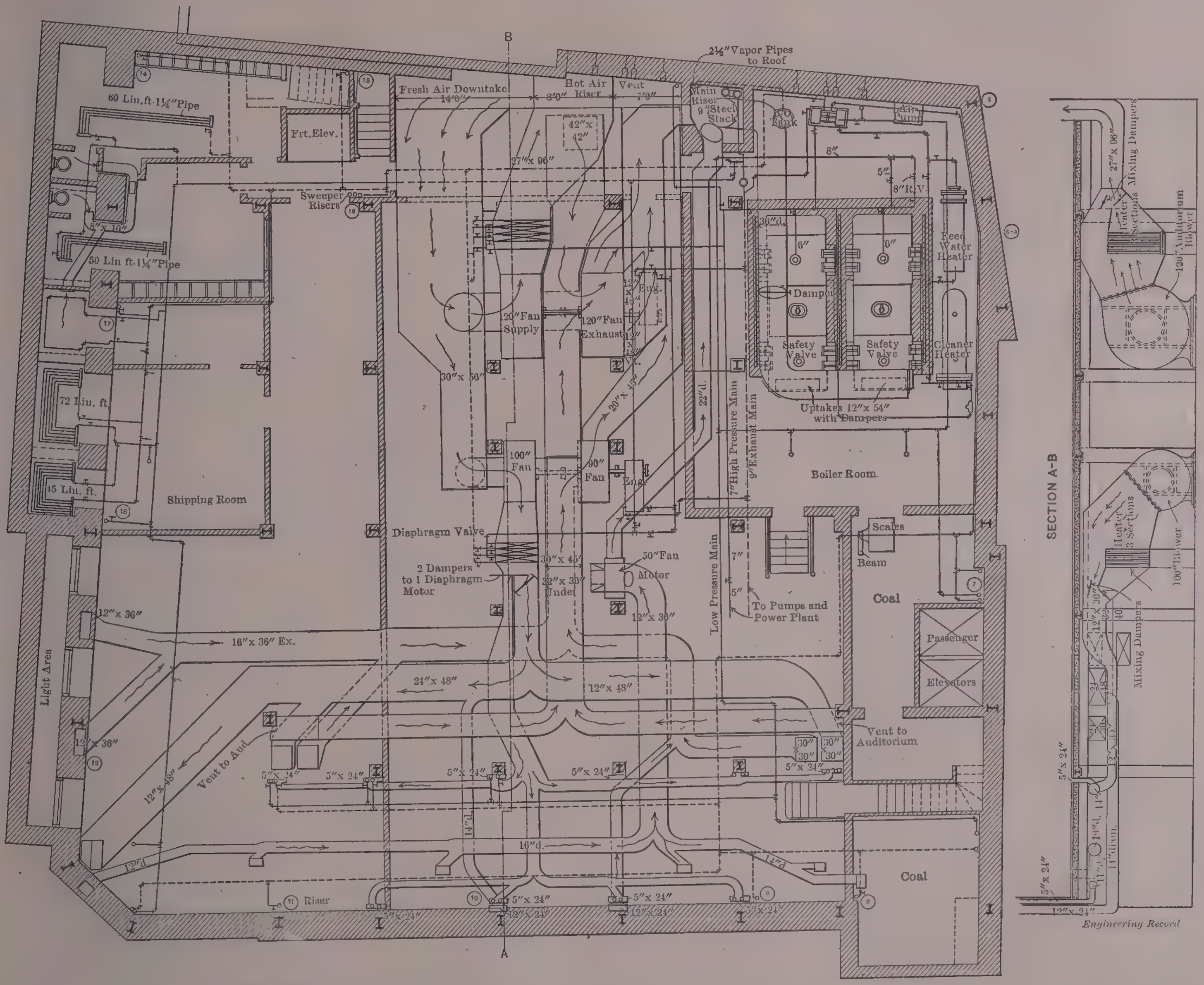
A gasoline-electric car has been built for experimental use between Cleveland and Willoughby on the Lake Shore & Michigan Southern Ry. It is nearly 44 ft. long and has seats for 42 passengers. Power is furnished by a 220-h.-p. gasoline engine driving a generator, the system being that developed by Pres. F. L. Chase, of the Jamestown, Chautauqua & Lake Erie Ry. All the machinery is below the floor, and the car may be operated from either end.

A 9,700-H.-P. Turbine of the single horizontal spiral-case reaction type will be constructed for the Chico station of the California Gas & Electric Corporation. It will run at 400 r.p.m. under a 550-ft. head.

The Mechanical Plant of the Ford Memorial Building, Boston.

The Ford Memorial Building is an eight-story, 90x100-ft. steel and brick building recently completed for the Boston Baptist Social Union at the corner of Ashburton Place and Bowdoin Street, Boston. The basement, first and second floors are used for religious and social purposes, and the remainder rented for offices. On the first and second floors is a 65x90-ft. assembly hall with balcony, which has a seating capacity of about 1,200, or 600 at banquet tables, and the basement contains a 30x70-ft. social hall. The top floor is devoted to committee rooms, storage and other purposes connected with the work of the Union. The hall is surmounted by a domed ceiling with skylight in a 35x45-ft. areaway, extending to the top of the building as a light court. The sub-basement, 86x115 ft., is used for a shipping room, janitor's quarters, and the mechanical equipment of the building.

The mechanical plant, which occupies the greater part of the sub-basement, consists of a 29x44-ft. boiler room at the rear corner, a 13x65-ft. coal storage space next the street and a space 60 ft. in width and of the full depth of the building devoted to the ventilating machinery, the electric lighting apparatus, elevator plant and other machinery. The sub-basement has a clear height of 12 ft. under floor beams, with the exception of the boiler and coal rooms, which have 16½ ft., giving somewhat limited space for overhead piping and ventilating ducts, so that considerable complication was inevitable; by careful location of apparatus, however, an arrangement has been secured which has proved convenient and comfortable. The handling of coal from the street to the boiler furnaces is facilitated by the location of the coal room between the boilers and the street, so that coal is dumped into the storage space through coal holes in the sidewalk and thence handled direct to the boilers by barrows. A platform scale in the doorway of the coal room permits weighing the coal for fuel records, as it is wheeled into the boiler room. The capacity of this coal storage is about 200 tons.



Sub-Basement Plan, Showing Heating and Ventilating Systems, Ford Memorial Building.

Boilers and Accessories.—The steam generating equipment consists of two horizontal return tubular boilers, 72 in. in diameter by 16 ft. 5 in. long, designed to carry a working pressure of 100 lb. and rated at 110 h.-p. each. Each has 116 3-in. tubes, 15 ft. long, expanded into ½-in. heads, and a shell of 7/16-in. open-hearth firebox steel, with triple-riveted double butt-strap joints for the longitudinal seams. They are hung in their settings by four gun-iron brackets on either side which rest on cast-iron bearing plates, the three to the rear on either side having roller bearings to allow for movement of the shell in expansion and contraction. The boiler settings are of the Sidney Smith system with coil pipe heaters on either side of the firebox and are equipped with the Smith smoke preventers. The walls are 24 in. thick at the sides and 18 in. at the rear with 2 in. air spaces and firebrick linings, and have Martin shaking grates with an effective grate area of 36 sq. ft. per boiler. The furnaces are 28 in. deep from boiler to grate bars, with 30 in. ash pits, and the shells have 16-in. overhanging fronts, each with a 12x54-in. flue opening. The breaching is of ⅛-in. iron and 36 in. in diameter, and leads to the rear of the boiler room where a connection is made in a pipe shaft 5 ft. square, to a 36-in. steel stack rising 134 ft. to the roof line. The lower 20 ft. of the stack is of 7/16-in. steel, half of the remainder ⅜-in., while the upper 57 ft. is of 5/16-in. steel.

The boilers are fed by a duplex receiver pump for the return of condensation from the heating system, which is supplemented for reserve purposes by a 1½-in. Lee ball injector. The pump is a 5¼x3½x5-in. Warren brass-fitted feed pump with condensation receiver, into which the discharge from all returns and traps is piped for its return to the boilers as it accumulates; make-up is supplied from the city service direct to the receiver. The pump is controlled in feeding by a Waters automatic pump governing valve, and the delivery line is fitted with a 1½-in. Crosby safety relief valve set at 120 lb. The feed piping consists of a 1½-in. brass line extending from the feed connection to the boilers, each of which is 3 in. above the upper row of tubes and extends within to an internal rear outlet, to the feed heater and thence to both the pump and the injector. The heater is a 24x96-in. Davis Berryman closed feed water heater of 100-h.-p. capacity, which has a 2½-in. connection to the low-pressure heating main and a 2-in. live steam connection. The blow-off connections consist of a 4-in. pipe tapped to the bottom of each boiler shell, 12-in. from the rear end and reducing to 2½ in. outside the brickwork and leading through, first, a 2½-in. Pratt & Cady asbestos-packed plug cock and then a Chapman gate valve to a main blow-off line of similar size, which extends back to a blow-off tank at the rear. The latter tank is of heavy cast iron 24 in. in diameter by 48 in. deep, and has a 2½-in. overflow to the sewer so connected that it will always remain partly filled. This tank is vented by a 2½-in. vapor connection extending up through the pipe shaft to a point 2 ft. above the top of the smokestack.

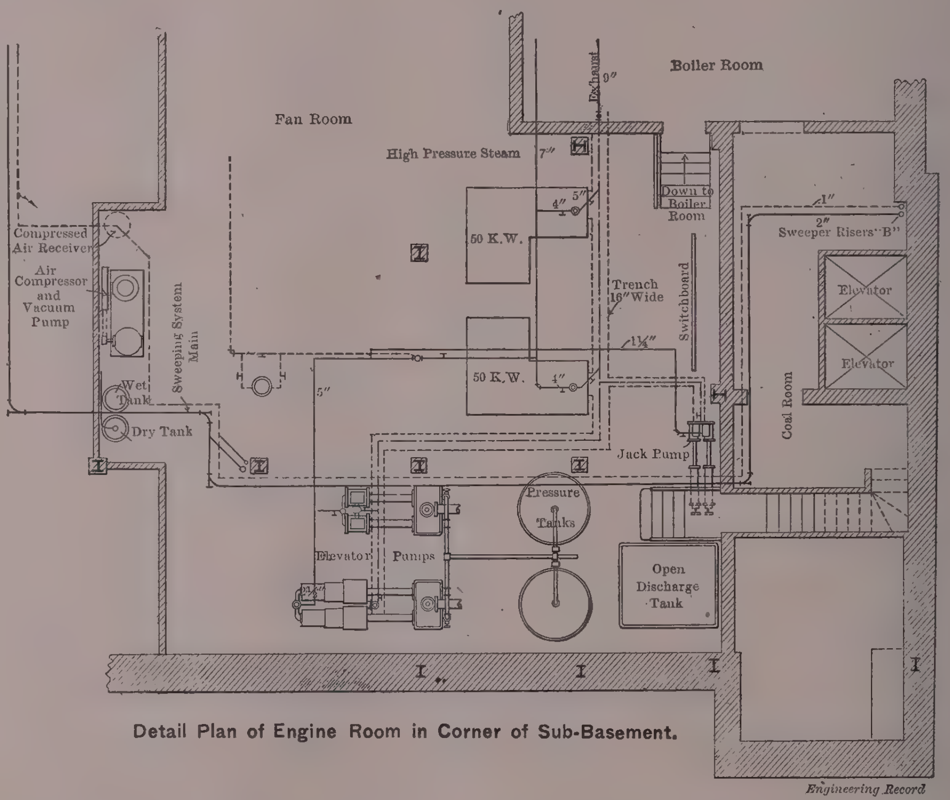
Steam Piping.—The high-pressure steam piping consists of a 12-in. header over the boiler setting at the rear with 6-in. branches to the boiler nozzles. From this header the various supply connections to the steam-using machinery are made, that for the engines and elevator pumps consisting of a 7-in. line extending through the boiler room to the front, from which 4-in. branches are taken off to each electrical generating unit, a 5-in. branch to the elevator pumps and a 1¼-in. branch to the jack pump. All of these branches have steam separators of the direct horizontal pattern which are drained automatically to the pump receiver by steam traps, as are also all ends and pocket points in the high pressure steam piping.

The exhaust steam system consists of a 9-in. line which is laid in a trench in the engine room and is thence carried up and through the boiler room to the heating system connections and to a riser in the pipe shaft in which the smoke stack is located. It has 5-in. branches from each of the generator engines and a 5-in. and a 2-in. line from the elevator pumps. At the rear of the boiler room the exhaust connection from the boiler feed and air pumps and also from two blower engines located in the fan room adjacent joins in, beyond which the exhaust is passed through a direct horizontal-pattern oil extractor before entering the low pressure heating main. This oil separator is automatically dripped through a trap, which discharges to the blow-off tank. In the pipe shaft at the rear of the boiler room the exhaust main is carried up as a 9-in. riser line to the attic floor, where connection is made to a distributing main supplying the heating system risers and thence to the roof, where connection is made through a Davis noiseless back-pressure valve to the exhaust head. Flexible wire ropes are dropped back from the back-pressure valve lever through the pipe shaft to the sub-basement so that it may be operated from the boiler room if necessary. The exhaust steam connections to the feed-water heater and the hot water heater in the boiler room are taken from an auxiliary low-pressure heating main in the boiler room, into which the exhaust main delivers.

Engines and Generators.—The electrical generating equipment of the plant consists of two 50-kw, direct-connected reciprocating engine units, consisting of simple Harrisburg-Fleming engines operating Bullock compound engine-type generators, which are installed in duplicate, either being capable of carrying the normal load in the building. Each engine is a 12x12-in. side-crank engine, with piston valve and the Harrisburg centrally-balanced centrifugal inertia governor, and is designed for operation to its capacity at 300 r.p.m., with 85 lb. of steam and a back pressure of 5 lb. The speed regulation effected by the governor is guaranteed for a variation of not over 3 per cent. with load changes between no load and full load. The units occupy floor spaces of 8x10 ft., the two units, which are rights and lefts, occupying together a total floor area of 10x18 ft.

The electrical generators are Allis-Chalmers-Bullock six-pole cumulative compound machines, wound for a voltage of 110 volts at no load and 115 volts at full load and are capable of operating at 25 per cent. overload continuously. The machines are designed for low current densities, as follows: 1,500 cir. mils per ampere in the fields, and 630 cir. mils per ampere in the armature, while the brushes carry a maximum of 30 amperes per square inch. It is intended to operate these machines upon the plain two-wire system, although the wiring of the building is convertible to the three-wire system, so that the Edison street service may be used at any time desired.

Heating System.—The heating of the building is accomplished in general by the direct-indirect system, which is supplemented on the lower floors by indirect heating in connection with the ventilation system. Exhaust steam from the power plant is utilized, with supply to radiation on both the two-pipe and one-pipe systems, the returns operating by gravity throughout. The upper floors are supplied on the down-feed system by drop risers connecting in the attic above the eighth floor with a distributing main from the atmospheric exhaust riser, while a low-pressure heating main encircling the sub-basement supplies such radiation on the basement, first and second floors as is inaccessible to the drop risers. The drop risers all feed on the one-pipe system, and are drained by a system of return lines in the sub-basement which discharge by gravity into the pump receiver for return to the boilers.



Detail Plan of Engine Room in Corner of Sub-Basement.

The low-pressure heating main originates in the exhaust steam header at the oil separator at the rear of the boiler room, where branch connections are made to the sub-basement heating mains and also the live steam connection for supplementing the exhaust in severe weather. The latter consists of a 6-in. branch from the high-pressure steam header to a 6x8-in. Waters lever-pattern reducing valve, which delivers through an 8-in. line to the sub-basement main and to the exhaust riser for the attic distributing main. This attic main is an 8-in. line which joins the 9-in. atmospheric exhaust riser just beneath the back-pressure valve and is carried around the building to supply sixteen drop risers. It is pitched 1 in. in 10 ft. with the flow of steam for drainage, and careful provision is made for expansion by swiveling loops at each bend. The drop riser run-outs are in all cases connected to the bottom of the main, pitching sharply toward the riser for free drainage, and are also connected by swiveling loops to allow for movement in expansion and contraction, the risers all being anchored to the building framework at the fourth floor. The drop risers are for the greater part 2½-in. lines, although in certain sections 2 and 3-in. pipe are used. The branches from these risers supplying radiation upon floors above the second are in all cases made on the ceiling of the floor below in order to effect proper drainage with the one-pipe connections.

Inside rooms are equipped with radiation in the proportion of 1 sq. ft. to 6 sq. ft. of floor area, while in the outer rooms the proportion varies from 9 to 11 sq. ft. of floor per unit of radiating surface, according to the amount of window glass and exposure. The radiators are for the greater part located beneath windows, where 26-in. Zenith direct-indirect radiators are used, but where wall radiators are employed they are of the Colonial pattern, of 7 sq. ft. per section. The air supply to the direct-indirect radiation is taken in through the window sills and down through ducts built into the wall to the radiator bases. The window sill openings are so arranged that when the lower sash is down the duct is closed, and is opened by raising the sash 3 in., which uncovers the duct, although the sash is not above the window stool.

The heating main in the sub-basement consists of a 3 and 3½-in. pipe leading to opposite sides of the basement to supply radiation on the basement, first and second floors, and a 2½-in. branch to the indirect heating stacks. From these mains there are supplied several short risers extending up to the first and second floors for the operation of radiation in the social hall and auditorium, and in addition a number of radiators distributed in the basement are supplied directly from it. The ten radiators in the vestibule of the main entrance to the auditorium are supplied by a special arrangement of riser connections, which are carried up through fresh air ducts which deliver through those radiators; they are thus effectively concealed and also are of some value in pre-heating the air delivered through the ducts. All of the exposed risers and low-pressure heating mains are covered with an insulation of wool-felt 1 in. thick, having an internal layer of heavy asbestos paper and an external covering of heavy sheathing paper, over which is sewed 10-oz. canvas in continuous lengths from floor to ceiling.

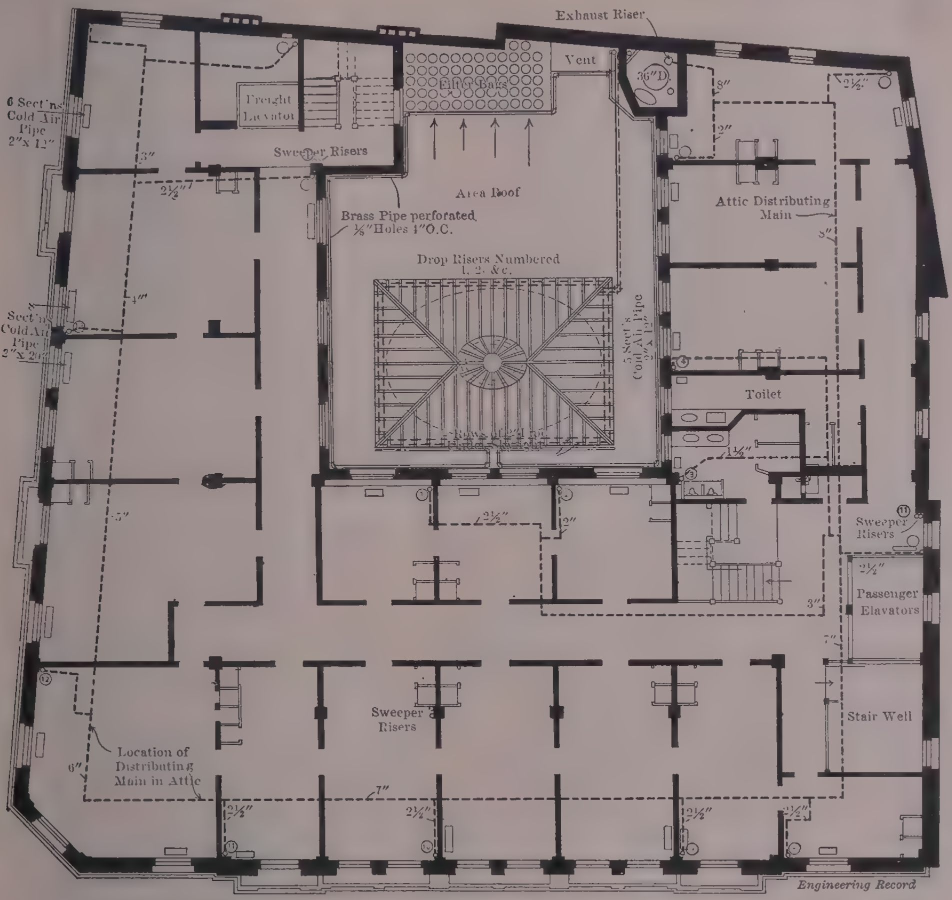
The arrangement and amounts of radiation on the basement, first and second floors are such as to provide for partial heating only, being intended more to take off the chill in the rooms prior to occupancy rather than being depended upon for complete heating, which permits the indirect systems to be shut down when the public rooms are not in use. In the main auditorium and also the social hall in the basement radiation is installed only at the entrances and under the windows and skylights. All of the radiation upon these floors is operated upon the two-pipe system and most of it is under automatic control. For the returns there are ¾-in. risers carried up to various radiators and groups of radiators which connect at the ceiling of the sub-basement with return mains leading back to the boiler room, where they discharge into the pump receiver. These return mains also receive the drip connections from the sixteen drop risers, which connections vary from 1 in. to 2 in. in size, according to the size of the drop riser. Automatic temperature regulation by the system of the Standard Temperature Regulation Co. is fitted to the four radiators in the social hall in the basement, on all of the ten radiators in the main vestibule on the first floor, and two radiators in the committee room upon the second floor. The thermostats are of ornamental pattern, fitted with thermometers, and have key adjustments so that they can be set for any temperature desired from 50° to 80° F. Compressed air for the operation of the temperature control system is supplied by a Westinghouse locomotive type air compressor which is fitted with a governor for automatically maintaining a pressure of 15 lb.

Ventilation.—The ventilating systems installed are confined to the public portions of the building on the basement, first and second floors and are arranged on the downward method of ventilation. The blowers for both fresh air and exhaust are in the sub-basement, from which extensive systems of duct work upon the sub-basement ceiling distribute to supply risers. There are two blowers for supply and three for exhaust, which have been installed in novel combinations for driving. Both the supply and exhaust blowers for the main auditorium, which are 120-in. full-housed steel plate fans, are driven in tandem by a single 8x8-in. horizontal center-crank engine. A second similar equipment consists of a 100-in. full-housed steel plate fan for supply of air to the social hall in the basement and to the committee and auxiliary rooms on the first and second floors, and a 90-in. fan for exhausting from these rooms, both of which are also driven in tandem by a 7x8-in. similar horizontal engine. The remaining fan is a 50-in. exhaust blower which serves an independent system of vents from dressing-rooms, toilets and the coat rooms in the front section of the basement. The 120-in. blowers have 6-ft. blast wheels and, operating at 200 r.p.m., have a capacity of 18,000 cu. ft. per minute each. The 100-in. and 90-in. blowers operate at 250 r.p.m., the larger unit having a capacity of 13,000 cu. ft. and the smaller 9,000 cu. ft. per minute. The supply here exceeds the exhaust capacity on account of extra duct capacity carried up to supply the main vestibule. The 50-in. exhauster is driven by a 2½-h.-p. Crocker-Wheeler direct-current motor and has an exhaust capacity of 3,000 cu. ft. per minute. The blowers and engines operating them, together with the heating stacks, were furnished by the Massachusetts Fan Co., of Waltham, Mass.

The fresh air supply systems have their intake through a filter chamber on the areaway roof above the main auditorium, from which a duct 3½x14½ ft. in size, is carried down at the rear of the stage and across to the blower intake connections. The filter is of the Woodbury bag type, consisting of 62 bags of unbleached cheesecloth, 12 in. in diameter by 6 ft. long, which are suspended from a horizontal diaphragm across the intake chamber. This chamber is a sheet metal enclosure 8x12 ft. in plan, with a protecting hood above extending out over the adjoining roof, so that still air is received and the intake opening, which is 2x12 ft. in section, is covered with a ¼-in. mesh wire screen. The frame or diaphragm carrying the bags is a horizontal sheet of No. 20 galvanized iron fitted across the chamber near the top with 62 12-in. collars 6 in. deep, through which the filtering bags are supported. Each bag has four metallic grommets at its top causing it to fit tightly over the supporting collar, so that all air passing is directed through the filter bags.

The heating stacks located in the delivery ducts of the two fresh air supply fans are three-section, four-row tempering coils. That for the auditorium system has 513 lin. ft. of pipe per section, a total of 2,052 lin. ft. or 708 sq. ft. of heating surface, while the 100-in. blower system has a toal of 1,448 lin. ft. of 1-in. pipe or 500 sq. ft. of heating surface, the capacity of either coil being sufficient to heat the maximum amount of air delivered by its system from zero to 80° F. when supplied with steam at 80 lb. pressure. These tempering coils are operated with hand control, each section having a 2-in. valved supply connection and a 1¼-in. drip connection to the return system. The steam main supplying them has duplicated connections, one to the low-pressure heating main in the sub-basement and the other to the main high-pressure steam line, which supplies steam to the blower engines, so that steam may be admitted to the coils at boiler pressure if desired. Further control of the temperature of the air delivered is available by mixing dampers in the main ducts beyond the heating stacks, by means of which air may be by-passed around the heater, passed entirely through it, or in any combination of the two. The mixing dampers of the auditorium supply are ordinarily controlled from thermostats in the auditorium, but there is a second or limiting thermostat in the hot air duct, so connected that, should the temperature of the air delivered drop low enough to be troublesome to those nearest the fresh air openings, it would automatically control the mixing dampers until the auditorium needed air at temperatures above the setting of this thermostat; then the auditorium thermostats would come into action again.

The arrangement of fresh air supply ductwork and outlet connections for the main auditorium is of the downward supply type, from a series of plenum chambers above the auditorium ceiling. The 120-in. blower delivers through a 3½x8-ft. hot air riser at the rear of the stage which is carried up to a point beneath the filter chamber and thence longitudinally across by a 30x96-in. connection to the various hot air chamber divisions which extend over the greater part of the auditorium ceiling. The subdivision of these chambers is in duplicate over either side of the auditorium, each half of which is supplied by an 18x19-in. branch connection from the main supply duct, no branch or chamber being smaller than 12x30-in. in cross-section. From the bottom and sides of these chambers 8x8-in. outlets are taken off at 30-in. intervals, the openings of which are all concealed in the soffits of the auditorium ceiling cornices. There are in all 323 of these openings, giving a combined outlet area of 144 sq. ft., so that with the system operating to its full capacity, delivering 18,000 cu. ft. of air per minute, an average velocity of outflow slightly over 120 ft. per minute is obtained. This



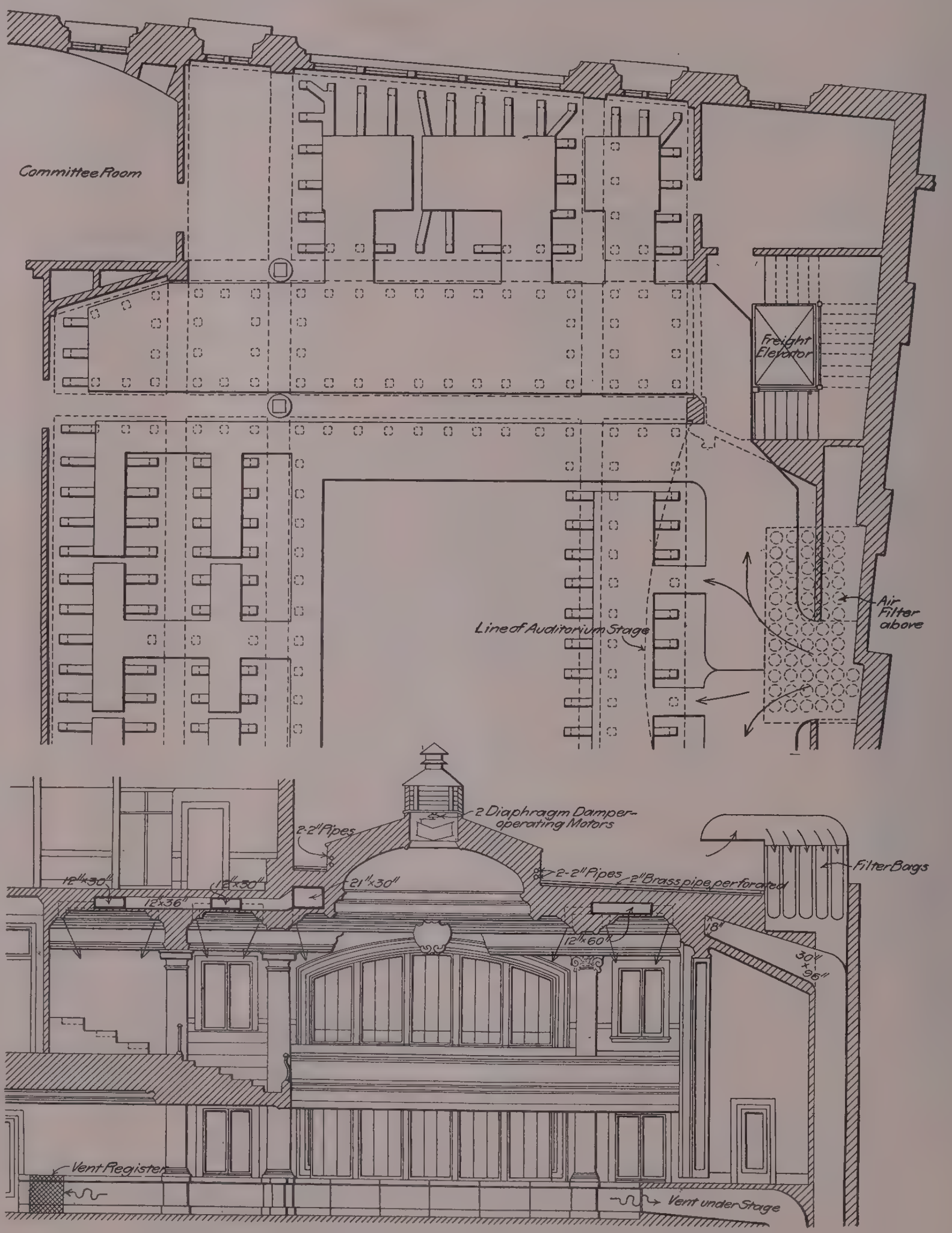
Third Floor Plan, with Arrangement of Attic Supply Connections to Drop Risers Indicated.

rate of ventilation provides for the supply of 30 cu. ft. per minute per person for an audience of 600, or 15 cu. ft. per minute on those few occasions when the auditorium is used to its full seating capacity. Each outlet branch connection is provided with an adjustable damper by which the volume of outflow may be adjusted as required, all of which were set by anemometer indications. At the rear over the galleries where people sit very close to the ceiling the velocities of outflow were adjusted to 50 ft. per minute or less, while over the center of the auditorium velocities of 500 ft. per minute were provided for to force the air directly to the floor.

The other fresh air supply system delivers through two lines of delivery duct, one a 32x40-in. line from which 30x30-in. risers are carried up to 30x36-in. registers 9 ft. above the floor of the social hall in the basement for the supply of 6,750 cu. ft. of fresh air to this room per minute. This provides ample ventilation for an assembly of 225 persons in the hall. A pair of 12x36-in. riser ducts lead from this system to two 16x30-ft. committee rooms, one on the first and the other upon the second floor at the corner of the building, supplying approximately 1,700 cu. ft. per minute to either rom. The other line, a 12x30-in. duct, supplies a series of ten 5x24-in. risers, which are carried up to openings at the rear of the corridor radiators for the supply of superheated air in the entryway to the main auditorium. As previously stated, there are ten radiators in the large corridor entrance on the first floor, which have heating surfaces varying from 32 to 57 sq. ft. depending upon the location. The steam supply and return connections for each of these radiators are carried up from the basement through the 5x24-in. air supply ducts which discharge through them. The control of both the direct radiation and the fresh air supply to this corridor is entirely automatic, that for the air supply connection consisting of a motor-operated damper in the 12x30-in. branch duct in the basement, which damper is under the control of a thermostat in the main vestibule. This damper-operating motor is also connected to a control damper within the 32x40-in. delivery line from this blower by an interconnecting link so attached that when the damper in the 12x30-in. duct is entirely opened, that in the larger flue is closed to an angle of 45° so as to partially shut off the supply to the social hall and committee rooms. The purpose of this is to partially shut off the supply to the latter when the people are gathering and the corridors need the most heat, while after the people have assembled, the large damper will open nearly wide and the small one is thus partially closed, giving the social hall the greater portion of the ventilation.

The ventilation of the main auditorium is accomplished by the 120-in. exhaust fan, driven in tandem with the auditorium supply blower, which exhausts from four 36x36-in. registers at the rear of the room, and from the space beneath the auditorium stage, the entire front of the stage being made to serve as a vent register, the opening in which is a fancy grill register 18 in. x 36 ft. in size. The velocity of inflow through this register space is, like that from the fresh air supply openings in the ceiling, scarcely more than 120 ft. per minute. The space beneath the stage is lined on the top, bottom and sides with No. 26 galvanized iron, which converges at the rear to a 42x42-in. duct leading down to the exhaust fan intake. The vent discharge from this fan is made through a 41x41-in. connection, joining with a 20x48-in. duct from the 90-in. exhaust fan, the two leading to a 3x7-ft. vent riser discharging above the areaway roof. An additional vent connection from the main hall is provided at the top of the oval glass dome surmounting the auditorium ceiling, in two large dampers which are operated simultaneously by a damper control motor similar to that used in connection with the temperature regulation system; this damper motor is arranged to open and close the dampers through a system of piping and three-way cock in the boiler room, for the convenience of the engineer. The auditorium ventilating system has been found capable of easily meeting the requirements, maintaining an even temperature during the opening night when the hall was filled for four hours, within 3° of that at which it was started; also no difficulty was experienced in delivering air as low as 50° F.

The 90-in. exhaust fan has two 30x30-in. vent riser connections to exhaust registers at the floor of the social hall in the basement above, two 12x36-in. vent connections to the corner committee rooms on the first and second floors and a 12x24-in. vent to the smaller committee rooms on the second floor. The motor-operated 50-in. exhauster serves the auxiliary rooms at the front side of the basement, including the toilet and dressing-rooms, coatroom and corridor, in which there are three 12x18-in. and three 12x15-in. vent registers at the floor line.



Details of Overhead Plenum Chamber System of Supply to Auditorium.

Natural ventilation is used to a considerable extent at the rear of the basement and on several of the upper floors. For this purpose vent connections are run into the pipe shaft in which the boiler smoke flue and exhaust steam risers are located and serve to create a strong induced draft. A 36x72-in. duct is carried in the sub-basement from the pipe shaft to vent connections through the floor above to a restaurant and its pantry. Upon the basement level an 8x16-in. vent connection leads across to the rear corner of the building and thence downward into the janitor's toilet and locker rooms in the sub-basement for their ventilation. On the basement, first and second floors there are 12x18-in. vent connections carried into the pipe shaft for local ventilation from a kitchen and other auxiliary rooms adjoining, behind which register openings, deflectors or diaphragms are carried up 6 ft. above the register to prevent back drafts out of the shaft.

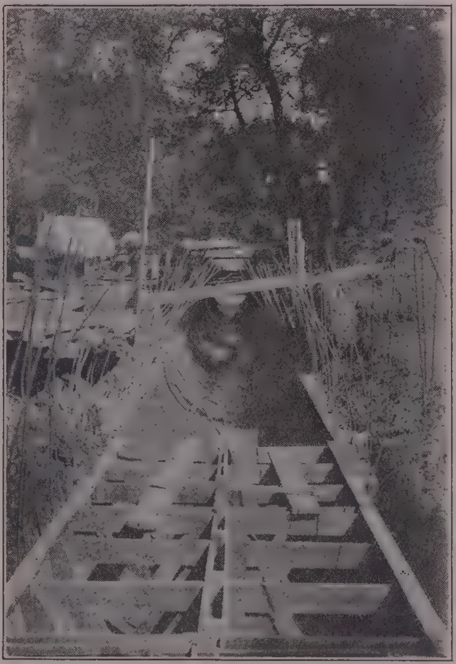
Elevators.—Two passenger elevators have been installed in the building at one end of the main corridor near the front, which have a travel from the basement to the eighth story floor, a total rise of about 92 ft. and a freight elevator at the rear outside corner of the building, with a travel from the sub-basement to the eighth story, a total rise of 105 ft. These equipments are of the plunger type with three-way balanced piston valves for their operation. The passenger elevators have capacities for net loads of 2,000 lb. each at a speed of 400 ft. per minute and of lifting a maximum net load of 2,500 lb. The freight elevator has a rated capacity for 1,500 lb. at a speed of 300 lb. per minute and of lifting a maximum net load of 2,500 lb.; this elevator has, however, a connection to a safe-lifting pump by means of which loads of 10,000 lb. can be raised. The cars are all 4½x 6½ ft. in size, the two passenger elevators having cabs of ornamental metal work and annunciator equipments on the Pratt system.

The plunger cylinders are of steel pipe, tested to 500 lb. pressure, which are set in wells sunk by wet driving and lined with ⅜-in. casings down to solid rock. Plungers of steel tubing 6½ in. in diameter are used on all three machines and a detachable riser or guide is provided for attachment to the freight machine plunger when lifting heavy loads with the jack pump. The control valves of the two passenger machines are governed by pilot valves operated by hand levers in the cars in the usual manner, while the freight machine is operated by the ordinary hand-rope control, all three machines having automatic stop-valve mechanism for bringing the cars to rest at the top and bottom of the runs independent of the main control valves. The guides for the cars are of heavy T rails while those for the counterweights are of similar form, but lighter in weight. Double counterweight cables are used with counterweights of sufficient size and number to compensate the lifting capacity and speed of each throughout its run.

For the hydraulic pressure supply to the elevator machines a pumping plant has been installed, with connections on the closed tank system, which is capable of maintaining a pressure of 150 lb. per sq. in. with the passenger elevators each making a round trip every 1½ minutes and the freight machine making round trips every four minutes, all continuously. The pumping equipment consists of a compound duplex pump with cylinders 12 and 18x9½x15 in. in size, and a duplex pump with 14x9½x15-in. cylinders, either of which when running at a speed not exceeding 50 strokes per minute will operate the elevators at the above capacity. The pumps are Stilwell-Bierce & Smith-Vaile brass-fitted pumps of the plunger and ring pattern and are governed by Mason pump regulating valves to maintain a constant pressure. The jack pump for lifting safes and heavy loads is a 7x3x10-in. duplex outside-end-packed plunger pump of the same make, and has a separate system of piping leading to the freight machine control valve only.

The elevator equipment requires a system of pressure delivery lines of 4-in. pipe from the pumps to a duplicate equipment of vertical pressure tanks, each of a capacity of 3,000 gal., from which 6-in. lines lead to the control valves of the various machines. The latter discharge through a line of similar size to a large open wrought-iron tank of 2,600 gal. capacity, from which the pumps take their suction through an 8-in. line. Air spaces are maintained in the pressure tanks to about one-half their capacity by means of a Westinghouse locomotive air compressor. The entire elevator equipment, together with hydraulic plant and piping was installed by the Plunger Elevator Co., Worcester, Mass.

Sweeping Plant.—An interesting feature of the equipment of the building is the combination compressed air and vacuum sweeping plant installed by the Sanitary Dust Removing Co. This system is designed for the removal of dust and dirt of all kinds and has a capacity sufficient to operate two 12-in. air suction sweepers or one 12-in. suction sweeper and one combination compressed air and vacuum renovator, at the same time, from any two hose connection points in the building and to accomplish this with a high efficiency in the removal of dirt. The system has a 16x6-in. vertical vacuum pump and an Imperial duplex vertical single-acting air compressor with 6x8-in. cylinders, operated through Morse silent-chain drives by a 20-h.-p. Crocker-Wheeler direct-current motor. From these compressors, systems of piping extend to numerous outlet connections on all floors for the renovator hose attachments. In the vacuum connection to the pump there are two 24x36-in. dry and wet separating tanks so arranged as to remove thoroughly all dust and dirt from the rarified air before its passage through the vacuum pump. The compressed air pump delivers to the system through a 20x60-in. receiver tank, tested to 150 lb. and fitted with a 1-in. lever safety valve. The vacuum piping system consists of four 2-in. riser lines carried up to the upper floors at different parts of the building to outlets in the halls on each floor, which risers join in the sub-basement into a 3-in. main vacuum header leading directly to the dry-dust tank. The compressed air risers are of 1-in. pipe paralleling the 2-in. vacuum lines with ½-in. valved openings on each floor in the same manner as the vacuum risers. The wet-dust tank has a ¾-in. water supply connection and 2-in. discharge connection to the house drain for cleaning out. The test made of this plant upon its completion consisted of attaching 100 ft. of 1-in. hose to any two outlets in the system which were opened to the atmosphere, to determine the capacity in maintaining vacuum under those conditions; the vacuum gauge attached to the dust tanks registered under these circumstances a 12-in. vacuum continuously. The equipment of special appliances used in connection with the system comprises two 12-in. vacuum carpet cleaners, one 12-in. combination compressed air and vacuum renovator, two corner cleaners, two upholstery cleaners, two 6-in. stairway sweepers, two wall brushes, two hardwood floor cleaners and one blowing nozzle.



Constructing Invert of 7-Ft. Sewer at Des Moines.

The mechanical plant of this building was designed by the Richard D. Kimball Co., engineers, Boston, Mass. The steam plant and heating and ventilating equipment was installed by the Cleghorn Co. and the generating equipment and lighting installation by the James Wilkinson Co., both of Boston. The architects of the building are Messrs. Brainerd & Leeds.

WATER WASTE PREVENTION in Worcester, Mass., is so well attended to that 65 per cent. of the quantity furnished by the reservoirs is accounted for among the consumers, which is 15 per cent. better than the usual showing.

The Ingersoll Run Sewer at Des Moines, Ia.

By A. E. Holmes.

What is known here as the Ingersoll run sewer at Des Moines follows for about four-fifths its distance the general course of a creek in the suburban district of the west side, called Ingersoll Run. A resolution of necessity in 1906 caused plans and specifications to be made, the surveys having previously been completed, for a storm-water sewer with the total length of about 7,156 ft. The conditions required several different forms to be used on account of the necessity of connecting with a 42-in. sewer already in place, and this brought the flow line near the surface of the ground where the street had not yet been brought to grade.

The city had on hand something like 650,000 brick which had been taken from a street in the neighborhood, and it was required to use the best of these in a part of the brick construction, to reduce cost. Accordingly several designs were made of reinforced concrete, since there were enough brick only for the smaller sections. The result was a 7-ft. circular, and a 5-ft. by 10-ft. reinforced concrete sewer. The latter form became necessary on account of the limited space between the flow line and grade of the street, the lowest point in the street being but 2½ ft. above the top of the concrete slab. The final plans were for 680 ft. of 42-in. brick sewer, 950 ft. of 5x10-ft. reinforced concrete sewer, 3,135 ft. of 7-ft. reinforced concrete sewer, 1,439 ft. of 5-ft. brick sewer, 982 ft. of 4-ft. brick sewer, brick manholes for brick sewers and concrete manholes for concrete sewers. Six-inch and 12-in. vitrified pipes were placed for house and sewer connections. Brick sewers were all two-ring.

Bids for the entire above work were received in May, 1905, and varied from $33,000 to $63,000. The lowest bidder claimed a mistake and forfeited his bond of $1,000. When new bids were received he was once more the lowest bidder and got the contract for $39,000, the estimate being $37,960.55.

Construction began on the brick sewers first, and Portland cement mortar mixed 1 to 2 was used throughout.

The 7-ft. concrete sewer follows most of its distance the bed of the creek, so that some ditching and pumping was necessary to keep the water away from the work. The trench was dug to the form of the outside of the invert and the transverse ½-in. steel bars were then placed 1 ft. center to center. The template was then placed in position as shown in the photograph and the concrete, which was a 1:2:4 mixture, was placed between the trench and template. The difficulty with this construction was that in soft places the sides were apt to slide in and form a bad piece of bottom. The invert being completed, the top template was placed upon the lower one and the steel bars were bent over this and wired together. Longitudinal bars ¼-in. square were laid in the concrete as it was built up. Plain bars were used on this part of the work, and not corrugated bars, as marked on the drawings.

In the 5x10-ft. sewer the method of construction was much the same except the transverse bars were ½-in. Johnson corrugated steel bars placed as shown on plans. The invert was built first and allowed to set; then the sides and top were built together.

At the junction of the 5x10-ft. concrete sewer and the 42-in. sewer there was constructed an overflow and brick culvert, the latter coming under the 42-in. sewer and emptying into the overflow near its mouth. This was so arranged on account of the probable extension within a few years of the large concrete sewer further down Ingersoll Run.

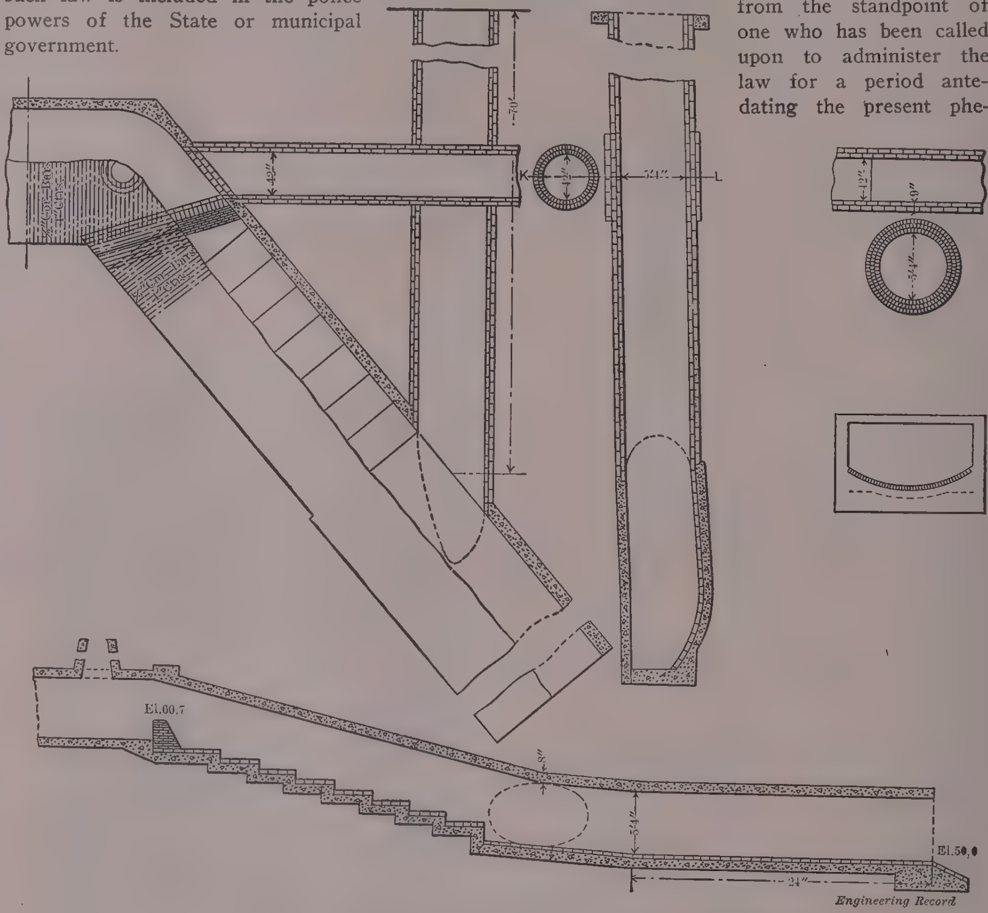
The overflow was of practically the same design of sides and slab as the 5x10-ft. sewer, but had a larger percentage of reinforcement. The bottom, however, was formed of steps, as shown on the plans, with two piles under each step. This form was used principally because it offered a better foundation and a shoulder for the piling, driven beneath the invert, which was necessary here as the bottom of the invert was in one place 2 ft. above the creek bed. It did not prove very difficult of construction.

A row of piling was also driven under the 42-in. brick sewer for a short distance. They were placed 8 ft. apart and upon the top of each pile was a concrete cradle 2 ft. x 2 ft. square and 6 in. thick. From all indications this construction is satisfactory.

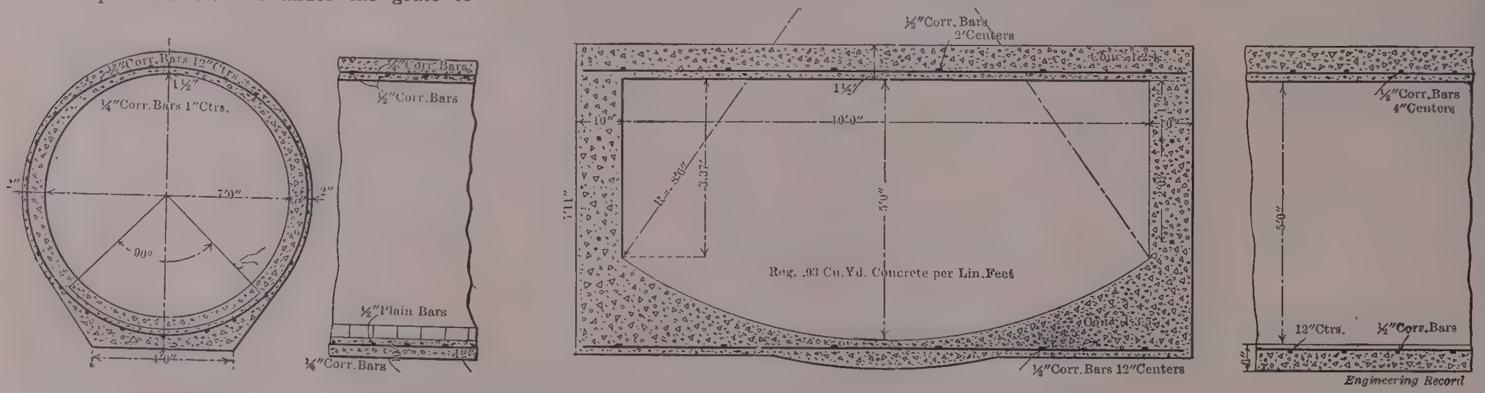
The work was done under the direction of Mr. John W. Budd, city engineer.

A New Fuel from Brown Coal.

A new fuel, Kaumazit, is made near Dresden from Bohemian brown coal. According to a paper by Herr Buchner, in the "Zeitschrift" of the Society of German Engineers, the coal is kept 24 hours in coke-oven retorts. The finished Kaumazit is removed from the base of the retorts every 3 hours and is cooled. The retort procedure first evaporates the hygroscopic water in the brown coal (25 and 28 per cent.), and then causes the distillation of the heavy hydrocarbons. The retorts are worked under a partial vacuum. The gases obtained from the retorts are cooled and scrubbed, and the purified gases are used part to heat the retorts, part to drive gas engines, and a surplus remains for sale to the various industries in the neighborhood. The thermal value of the Kaumazit obtained averages 6,749 kg.-cals. It contains 77.34 per cent. carbon, 14.9 per cent. ash, and 1.47 per cent. hydrogen, with 4.20 per cent. hygroscopic water. It is graded in three sizes, and is sold as fuel for suction gas-producers and for boiler firing, while the finest size is sold for the production of slow-burning briquettes. Analysis proves Kaumazit to be a fuel poor in gas and high in fixed carbon. It has a high ignition temperature. Boiler-firing with this fuel therefore demands closed ashpits and blowers under the grate to obtain the best results. With well-designed grates a boiler efficiency of 72.2 per cent. has been obtained. The air pressure is so regulated that when the fire-doors are opened there is neither air-indrawing nor flame emission, a result obtained by working with a chimney draft of 7 mm. of water and a blower pressure of about the same value. In the trials carried out with this fuel the excess air has only averaged 19 per cent. above that required by theory for complete combustion of the fuel. Kaumazit is, further, a smokeless fuel, and the cost in Dresden is so regulated that in most industries it can be employed so as to yield a saving of from 3 to 10 per cent. as compared with ordinary coal.



The Overflow of the Ingersoll Run Sewer System, Des Moines, Ia.



General Construction of Reinforced Concrete Sewers, Des Moines, Ia.

The Proper Legal Requirements for the Use of Cement Constructions.

Read before the Concrete Association and the National Association of Cement Users by Rudolph P. Miller, Chief Engineer, Bureau of Buildings, New York.

The prime function of a building law is the protection of the general public against the dangers resulting from: First, bad construction; second, hazardous surroundings; third, defective equipment; fourth, inadequate means of escape; fifth, unsanitary conditions. The enforcement of such law is included in the police powers of the State or municipal government.

The third, fourth and fifth of the dangers above specified may be entirely dismissed from consideration in this paper. They relate to the supplying of proper fire-fighting appliances in structures, and the affording of good and sufficient means of escape from fire or panic to the occupants of buildings, and securing healthful surroundings for them. They apply equally to all kinds of constructions, irrespective of the materials used. The other two dangers, bad construction and hazardous surroundings, do very materially concern the question under discussion.

The dangers of bad construction would include those due to bad materials, bad workmanship, including incompetent supervision, and bad design. (This is not the logical order, but this order is taken for convenience in this discussion.)

The dangers of hazardous surroundings are those attending the inability of a building to withstand attacks from outside sources, such as excavations on adjoining premises, but more particularly fire in adjacent structures. When we have provided against these in our laws, we have secured the essential requirements that constitute a satisfactory law. It is the object of this paper to consider what these requirements are, so far as they apply to the use of cement, and especially from the standpoint of one who has been called upon to administer the law for a period antedating the present phenomenal development of the cement industries.

Cement is used in different ways in building construction; most extensively in mortar, very largely in concrete, both plain and reinforced; in increasing quantities in building blocks; also for cement bricks, artificial stone, stucco, and in perhaps other less important ways.

In whatever way cement may be used in construction, its quality should be up to a certain standard, and it is properly within the province of the law-making power to fix that standard, or at least to recognize some standard otherwise established and recognized. This may be done either by giving a complete specification in the law, or authorizing the executive officer of the building bureau or department to prescribe, within proper restrictions, the requirements which all cements must meet. The former way is the less desirable, not only in the particular matter under discussion, but in all building law, as it retards progress and makes no provision for new materials and processes or improvements. Building laws should be sufficiently flexible to be capable of meeting new conditions. This can be best accomplished by laying down in the law only fundamental principles and investing the executive officer with power to fix the more definite requirements. That this power may not be abused, it should be restricted to such an extent as to require the publishing of all proposed requirements, and the holding of public hearings, if demanded, before the same become effective.

In the case of cement, the fundamental principles should be such as to secure strength and soundness. As to the more specific requirements, nothing better could be done than to adopt a standard specification promulgated by some organization of recognized national reputation, such, for instance, as that of the American Society for Testing Materials. No specification ever drawn satisfied everybody, but one presented by such an organization might well receive legal sanction, even though it does not in some particulars meet the views and criticisms of the building official immediately concerned.

The Completed Overflow, Des Moines Sewer.

Steps in Overflow, Des Moines Sewer.

As to strength of cements, the present Building Code of New York requires the tensile strength of neat briquettes to be:

For natural cements: After 24 hr. set in air, 60 lb. per square inch; after 1 day in air and 6 days in water, 120 lb. per square inch.

For Portland cements: After 24 hr. set in air, 120 lb. per square inch; after 1 day in air and 6 days in water, 300 lb. per square inch.

In the case of natural cements the requirements are still considered satisfactory, but for Portland cements the accepted present standard is higher, namely:

After 24 hr. in air, 200 lb. per square inch; after 1 day in air and 6 days in water, 500 lb. per square inch; that is fully 66⅔ per cent. better than the old standard.

This illustrates, in a measure, what has been said about the flexibility of law. As conditions improve, it should be possible for the building official to demand the use of the up-to-date material.

Neither the New York Building Code, nor any other building law that has come to our attention, makes any provision for soundness, and yet this would seem to be the more important characteristic of a cement. A contractor or speculative builder would possibly not care whether his structure lasted beyond the final payment or the transfer of the property, but the interests of the public demand that it shall. In some cases self-interest would also require lasting qualities. The manufacturer of concrete building blocks or cement brick could not afford to have his product disintegrate in six months or a year after it has been put into a building; and yet this would happen if his cement should be unsound.

So long as cements were used in constructions where the individual masses were large and unbroken, the importance of soundness in cement was not so apparent. But since the introduction of building blocks, and especially of reinforced concrete construction, this matter becomes of first importance. Imagine, if you will, the consequence of the disintegration of a concrete column, due to unsound cement, in the basement of a heavily loaded five-story warehouse.

Municipal inspection bureaus could not, of course, inspect all cements used in building operations, nor is it the function of the government to do so. The law should require, however, as it does in New York, that all brands of cements be tested under the supervision of the proper official, at such times and as often as may be deemed necessary; that a record of all cements answering the lawful requirements be kept for public information; and that no other cements be used.

The law should further prescribe that all cements used in important work, especially in work where the masses in the individual members composing the structure are comparatively small (compared to the entire mass), such as reinforced column and floor work or building block manufacture, should be tested for strength and soundness by the contractor or manufacturer at some reputable laboratory, and a certified copy of such tests filed with the proper building official.

Mortar and concrete, it may be said, are the forms in which cement for building purposes is always used. It is, therefore, quite within the province of the law to prescribe the characteristics of the other component materials. These may be one or several of a number of materials; sand, gravel, broken stone of many varieties, slag, cinders, broken brick, etc. The extent to which any of these materials is used will depend largely on local conditions. The proper proportions in which they are used vary with the material and the sizes used. To get the best results the mixture must be well balanced, the smaller particles filling the voids of the larger, and the cement completing the mass by binding all together. In consequence, it becomes difficult to prescribe mixtures and proportions that shall be lawful, and at the same time secure the best results, for any one of the several materials specified may not always run uniform in size, and the proportions would very properly be changed continually to meet the new conditions. How then shall the law control mixtures to secure safe and just results?

In the case of a material or mixture that is made up into shapes and units and sent to the structures to be used, a certain standard of strength should be fixed by law, and the maker should be required to test his product under the direction of the building official. If necessary or desirable, certain limiting proportions might also be prescribed, but so long as the product of any plant meets the prescribed standard of strength, the particular proportions or materials used are of small moment. This requirement would apply to such materials as building blocks, cement bricks, artificial stone, etc., or such as can be easily bought in the open market.

About nine months ago, the New York Bureau of Buildings promulgated certain requirements as to strength and other characteristics for materials of this nature, and the conditions under which tests shall be made and approvals issued. The requirements conditioning the acceptance of the materials were based on the results of an elaborate series of tests on common brick as delivered in the New York market, and on the theory that any new material should be at least as good as that most commonly used. These regulations containing the requirements were published in the technical journals, and it was hoped at that time that they would bring forth such discussion and criticism as would be useful in determining whether the requirements were fair or perhaps too severe. Thus far, no objections based on reliable data have been made, and this is probably due to the total lack of definite information.

Section 14 of the New York Regulations is as follows:

"14. The following requirements must be met to secure an aceptance of the materials: The modulus of rupture must average 450 and must not fall below 350 in any case. The ultimate compressive strength must average 3,000 lb. per square inch and must not fall below 2,500 in any case. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample) must not average higher than 15 per cent. and must not exceed 20 per cent. in any case. The reduction of compressive strength must not be more than 33⅓ per cent., except that when the lower figure is still above 3,000 lb. per square inch, the loss in strength may be neglected."

The Philadelphia Building Bureau adopted these regulations in toto at the time, but have recently modified them so far as they relate to concrete building blocks. Their requirements are as follows: "14. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture for concrete blocks at 28 days old must average 150 and must not fall below 100 in any case. The ultimate compressive strength at 28 days must average 1,000 lb. per square inch, and must not fall below 700 lb. in any case. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample) must not average higher than 15 per cent. and must not exceed 20 per cent. in any case. The reduction of compressive strength must not be more than 33⅓ per cent., except that when the lower figure is still above 1,000 lb. per square inch, the loss in strength may be neglected."

We are not prepared to defend these requirements against all criticism; in fact, any information of tests that would establish the correctness or the unfairness of these requirements would be most welcome. This much, however, must be said, that thus far several new materials have met the New York requirements, and among them, cement brick. No concrete building blocks have yet been tested in accordance with these requirements. While it would seem that some change is desirable for the benefit of the building block, it is believed that the Philadelphia requirements are too low. It may be true that by virtue of the larger size of the units, a wall built of building blocks has some advantages of strength over one built of smaller units, such as common brick, still so great a drop in ultimate compressive strength below that required for brick or stone concrete as is permitted by the Philadelphia regulations seems unreasonable. No one contends that an ultimate compressive strength of 2,000 lb. at twenty-eight days for concrete, or of 2,500 lb. for brick is too high, yet it is proposed to accept building blocks with an ultimate compressive strength of 1,000 lb. at twenty-eight days, and even then make no provision for extra thickness in a wall built of building blocks above that required for brick or Portland cement concrete.

In the case of reinforced concrete, however, the question of the mixture must be disposed of in a different manner. Reinforced concrete construction is put up in place. The component parts, concrete and steel, are differently disposed for varying conditions of shape, span and loading. The entire construction must be carefully planned beforehand, every part must be definitely fixed, and the size and position of each element must be determined by calculation. In order, therefore, that any governmental control in such a case may be had, a definite mixture must be used, the physical characteristics of which, crushing strength, modulus of elasticity, adhesive power, resistance to shear, are well known; and the law-making power is fully justified in prescribing such mixture for all work of that kind under its jurisdiction. What that mixture should be will again depend somewhat on local conditions, for it would certainly be out of all reason to prescribe a trap rock mixture in a locality where trap rock is commercially unobtainable.

The New York regulations permit a variation in the mixture from the prescribed proportions of 1:2:4, so long as it can be demonstrated by tests, under the supervision of the bureau, that the compressive strength at twenty-eight days does not fall below 2,000 lb. per square inch. Experience has shown that very little latitude should be allowed in this matter of variation of mixture, as it is practically impossible to properly control the construction where more than one mixture is used. If the designers could be held criminally responsible for their results, no limitations of this kind would be needed; but so long as the building authorities are held to a partial accountability they are fully justified in insisting on a single well-known mixture for reinforced concrete construction.

Before dismissing this question of materials and mixtures, one other commonly used mixture should be considered, namely, cinder concrete. The excellent fire-resisting quality of this concrete makes it a most useful building material. Its great lack of uniformity and its consequent unreliability in strength make it necessary to deprive it from consideration as a construction whose strength is calculable. The practice in New York is to insist on load tests on full-size constructions for every variation in span and detail of construction, in order to determine allowable working loads.

Floor constructions are here alluded to, as that is practically the only form requiring strength in which it is used. The factor of safety demanded is ten, that is the section of floor to be tested is loaded till it breaks, and one-tenth of the uniformly distributed breaking load is taken as the working load.

Good workmanship is important in all construction, but in no form of construction is it so important as in reinforced concrete; and in that form of construction it is no more nor no less important than good materials or good design. So far as law is concerned, however, workmanship may be dismissed in a few words. The law can simply demand that all possible care be exercised in securing it. It will always be secured if there is competent supervision. Competency is secured by study and experience. It is not necessary to go into such details as cautioning against freezing mortar, using cements that have begun to set, where there is competent supervision. There would be no end to these detailed requirements if once begun. How to secure competent supervision in all cases, especially where builders and owners are unwilling to pay for it (though it is an excellent investment), is a difficult problem. The following suggestions may, however, be a step toward the solution. Let it be made compulsory that every building operation shall be in charge of a licensed inspector or superintendent, who shall have received his license from a competent examining board, and who shall be criminally responsible for the work and for infraction of the law. The details of this plan have no proper place in this paper, for they are of general application and not peculiar to this form of construction.

For the design of a structure the designer must always be responsible. The supervision of the design by the building authorities should only be to assure that the allowable working stresses have not been exceeded, that the prescribed floor capacities are provided, that proper light and ventilation are secured, etc.; in fact, that the general provisions of the law are complied with.

To go beyond this is to relieve the designer of that much responsibility and to place it where it does not belong. Building departments or bureaus should be bureaus of record, and the records should be complete. The Prussian regulations on reinforced concrete go so far as to even demand that a copy of all calculations as to strength be filed, although they may not be checked over.

There is a great tendency to particularize in our laws and to add provision upon provision, to make more and more a complete specification of the law. Instead of this, as has already been stated, only fundamental principles should be included in the law. The designer should be allowed all possible freedom, but at the same time, he must be made absolutely responsible for his work.

So long as these conditions do not obtain, it is perhaps better that the law should go farther than necessary in prescribing limitations. Under such circumstances, it is to the interest of the good and honest designer and builder and users of cement that the law should err on the safe side and take a conservative position.

New York City was the first municipality in this country to prescribe regulations on the use of reinforced concrete. They were drawn after much study and considerable discussion among experts at a time when the construction was not widely known. That they have been fair and good is attested by the fact that with not many changes the requirements on that form of construction, laid down in the model building code recently proposed by the National Board of Fire Underwriters, are those of New York City. And these latter requirements were, as stated by one closely connected with their promulgation, the result of study, of suggestions and criticisms of many engineers and experts. Besides these two codes there are ordinances in Chicago, Cleveland and Denver.

Taking up in more detail the fundamental principles to be laid down for the guidance of the designers, these should include:

1. The allowable stresses in the materials.
2. The methods used in calculating the stresses produced.
3. The guiding principles in determining the resistance to these stresses.

It is generally conceded that the tensile strength of concrete should not be considered.

The New York, Chicago and Cleveland laws prescribe working stresses, but the proposed code of the National Board of Fire Underwriters prescribes a factor of safety applied to working loads and the use of ultimate stresses. It is not proposed to discuss here the superiority of either method over the other, as both will give safe results if intelligently used.

The following stresses per square inch should be used and are those prescribed by the laws cited, the ultimate stresses being those used by the National Board of Fire Underwriters:

	Working Stress. lb.	Ultimate. lb.
For extreme fibre-stress of concrete in compression	500	2,000
For shearing stress in concrete	50	200
For concrete in direct compression	350	...
For tensile stress in steel	16,000	...
For shearing stress in steel	10,000	...
For adhesion of concrete to steel	50	200

The Denver ordinance gives no stress values, but refers to a hand-book, a practice that is not to be commended. The Chicago ordinance permits a shearing stress in concrete and adhesive value of 75 lb. per square inch, which, in the opinion of the writer, is too high. On the tensile value of steel there is also a difference, only New York and Cleveland fixing a definite figure, 16,000 lb., and Chicago permitting one-third of elastic limit. On this point there is much opportunity for discussion. The writer believes a definite value should be adhered to, and that should be 16,000 lb. working stress.

It is generally believed that the adhesion of concrete to steel may be taken the same as the shear to concrete. The Denver law, however, prohibits the use of plain bars. This is an unjust limitation on the designer, so long as the safe limit of adhesion is not exceeded. When this occurs, all the laws are agreed that other provisions should be made. So, too, would it be an unfair requirement to prescribe the use of stirrups unless the safe resistance to shear is exceeded, or to insist on the use of certain bars to secure rigid attachment of stirrups. This is no more important than the placing of the tension bars in their exact position, which must be taken care of in the supervision of the construction.

The Cleveland law makes provision for compression in steel. This is unnecessary, as the allowable compression in the steel must depend on the assumption of the ratio of moduli of elasticity of the two materials, unless the steel is designed to take all the load, in which case we are no longer dealing with reinforced concrete.

The maximum ratio of length to diameter of columns is fixed at twelve in all, but the Denver law, where hooping is required when the ratio exceeds four.

In the calculation of bending moments and the determination of moments of resistance, the practice is quite uniform, and the New York provisions are suggested as sufficiently full:

"13. The following assumption shall guide in the determination of the bending moments due to the external forces. Beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor plates, when constructed continuous and when provided with reinforcement at top of plate over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than $WL/10$; the bending moment may be taken at $WL/20$ in the case of square floor plates which are reinforced in both directions and supported on all sides. The floor plate to the extent of not more than ten times the width of any beam or girder may be taken as part of that beam or girder in computing its moment of resistance.

"14. The moment of resistance of any concrete-steel construction under transverse loads shall be determined by formulæ based on the following assumptions:

"(a). The bond between the concrete and steel is sufficient to make the two materials act together as a homogeneous solid.

"(b) The strain in any fibre is directly proportionate to the distance of that fibre from the neutral axis.

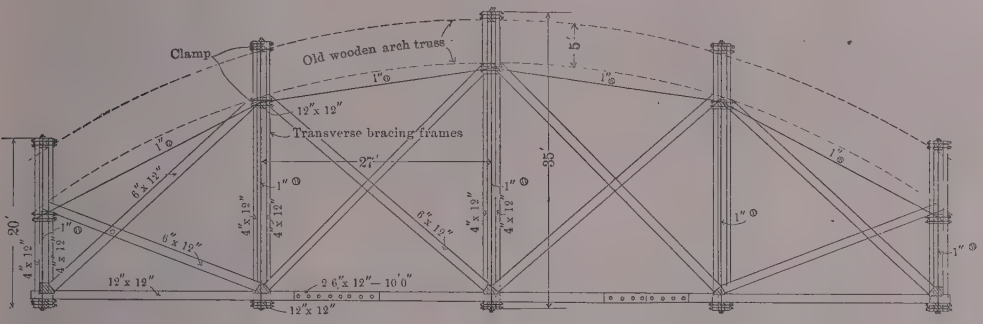
"(c). The modulus of elasticity of the concrete remains constant within the limits of the working stresses fixed in these Regulations.

"From these assumptions it follows that the stress in any fibre is directly proportionate to the distance of that fibre from the neutral axis.

"The tensile strength of the concrete shall not be considered."

It is believed that these provisions go as far as necessary (they are somewhat more elaborate in the National Board of Fire Underwriters' Code), and do not hamper the designer unnecessarily. For a comparatively new form of construction, in which uniform practice is not yet thoroughly established, it cannot be said that they go too far.

Regarding the use of concrete building blocks in the design of new buildings, an important question arises as to the height to which they shall be allowed in walls. Chicago restricts their use to dwellings and stables not more than two stories in height. Cleveland allows them for buildings of ordinary (non-fireproof) construction four stories in height. Philadelphia permits them for six-story buildings. Their use is not yet allowed in New York (Manhattan).



Framing Used in Moving Long Roof Arch.

Concrete is generally assumed and frequently accepted as fireproof. The later laws on concrete recognize it as fireproof and prescribe minimum thicknesses to be used for covering the embedded metal. That concrete is incombustible cannot be denied, that it will not disintegrate under fire cannot be maintained (stone and gravel concrete only being considered now). The New York Building authorities have made fourteen fire tests on concrete constructions, of which seven proved successful. It would seem that in the cases of failure the concrete when tested was too green, that is to say, it contained too large a percentage of uncombined water which was converted into steam and caused the disruption of the concrete. This makes it necessary to guard against the occupancy of concrete structures within the time required for the concrete to appropriate all its water. That a reinforced concrete building is far superior as a fire-resisting structure to a mill constructed building must be conceded; that it is equal to the best type of fireproof construction cannot justly be claimed.

The best practice in this particular is that given in the code of the National Board of Fire Underwriters, as follows: "Reinforced concrete construction may be accepted for fireproof buildings if designed as hereinafter prescribed; provided, that the aggregate for such concrete shall be hard-burned broken bricks, or terra cotta, clean furnace clinkers, entirely free of combustible matter, clean broken stone, or furnace slag, or clean gravel, together with clean saliceous sand, if sand is required to produce a close and dense mixture; and provided, further, that the minimum thickness of concrete surrounding and reinforcing members ¼ in. or less in diameter shall be 1 in.; and for members heavier than ¼ in. the minimum thickness of protecting concrete shall be four diameters, taking that diameter, in the event of bars of other than circular cross-section, which lies in the direction in which the thickness of the concrete is measured; but no protecting concrete need be more than 4 in. thick for bars of any size; and provided, further, that all columns and girders of reinforced concrete shall have at least 1 in. of material on all exposed surfaces over and above that required for structural purposes; and all beams and floor slabs shall have at least ¾ in. of such surplus material for fire-resisting purposes; but this shall not be construed as increasing the total thickness of protecting concrete as herein specified."

Of the fireproof quality of cinder concrete there can be no question, as already intimated. The thirty-six tests made under the supervision of the New York Building Bureau would remove any doubt in the matter.

On the fireproof character of building block walls very little is known. Information is much desired.

The weathering qualities of concrete, more especially in the shape of building blocks, should be fully and carefully investigated. Some freezing tests made for the New York Building Bureau on cement blocks indicated a tendency of the material to distend, and a loss in compressive strength of about 40 per cent. resulted. On concrete building blocks, the absorption is probably high (this is not based on actual observation), and a deterioration of the material in freezing seems likely. To guard against danger in this respect, the following New York provision is desirable: "That the freezing and thawing process must not cause a loss in weight greater than 10 per cent., nor a loss in strength of more than 33⅓ per cent., except that when the lower figure is still above 3,000 lb. per square inch, the loss in strength may be neglected."

To this may be added, that if the lower figure is still above 2,000 lb. per square inch, the loss may be as much as 50 per cent., but not in excess of that.

In conclusion, it may be said, that of all the suggestions made in this paper, the most important is the one fixing the responsibility for bad design and bad workmanship. It is decidedly in the interest of every cement user that so valuable a structural material as cement should be applied honestly and intelligently, leaving no chance for its condemnation because of improper or irresponsible work.

Moving and Raising an Old Wood and Iron Roof.

An interesting piece of work has just been completed in New York by the P. J. Carlin Construction Co., for the Riding Club, Fifty-eighth and Fifty-ninth St., near Fifth Ave. The club occupies a building originally designed by the late Carl Pfeiffer, architect, with a 64x107-ft. riding ring, spanned by two handsome wooden arches, running lengthwise. The horizontal thrust was taken up by combination trusses placed horizontally in the adjoining floor construction.

About twenty years ago additional property was acquired and to suit the increased membership of the club, the ring was widened to 104 ft. by moving the westerly truss 30 ft. to the west. The late George S. Morison, who was a member of the club, designed an efficient system of skewbacks and horizontal ties, relieving the adjoining floors of the strain. A new roof of 66 ft. span was built resting on the old wooden arches and providing for a 104x107-ft. ring.

The old roof had clear spans on all four sides and was supported only at the corners, where riveted vertical columns carried the ends of Howe truss arches of about 10 ft. rise, with a clear height of about 20 ft. from the ground to the intrados. At the panel points there were seated on the top chords vertical members forming the wall of the clere story rising above the crown of the arch. Every third vertical served as the end post for a light pin-connected iron transverse roof truss. The ends of the roof trusses were connected by light arch-like bracing, and at the ends of the buildings there were special gable trusses, deeper than the intermediate ones.

Last spring it was again found necessary to enlarge the capacity of the ring. For sentimental and economical reasons it was decided to retain the old trusses, but to place them to run east and west instead of north and south. To take the roof and the old trusses apart would have resulted in a heap of junk, and as it would have been useless to attempt their reconstruction with the old material, it was decided to turn the structure bodily.

The only bracing the roof had to depend upon was afforded by the sloping side roofs of about 20 ft. span, bearing upon the side walls. Since these did not form a part of the new plan they had to be removed and it was necessary for safety to prepare temporary bracing for the main arches before any part of the old building was disturbed. The design for this bracing assumed the form of a skeleton box 107 x 104 ft. in plan by 40 ft. high, consisting of 12x12-in. timbers and 1¼-in. tie rods. Diagonal bracing was provided for the top and bottom of this box and also for the sides and ends.

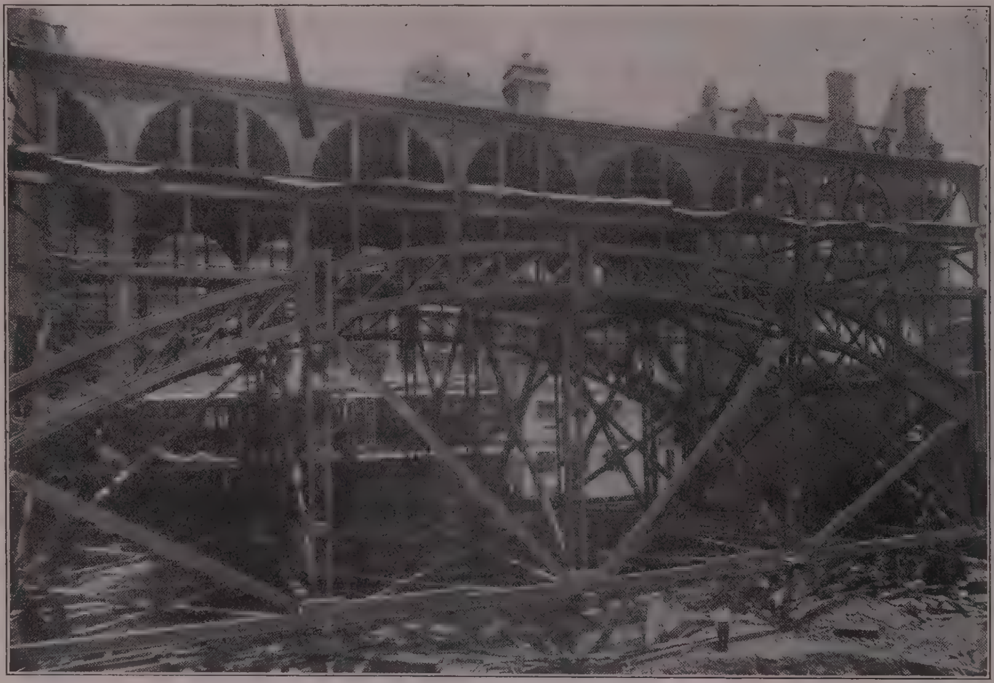
All this temporary trussing was supported by clamps on top of the old arches. The total weight to be lifted and moved was about 160 tons. A pair of 15-in. horizontal channels 7½ ft. long were fastened across the face of each corner column with bolts put through holes provided by temporarily cutting out rivets. These afforded reaction for pairs of 40-ton Dudgeon hydraulic jacks, which were placed under them and lifted the roof and bracing about 6 ft. It was then pulled back 40 ft. by two powerful crabs manned by four men, the structure moving upon rollers placed between steel plates. The next operation was the horizontal revolution through an angle of 90 deg., which was a complicated undertaking. Fortunately, there was an open space of about 30 ft. between two adjoining houses into which the corner of the building temporarily projected; without this it would have been impossible to perform the operation. The space, however, was so confined that it was necessary to move forward and backward, and swing the structure first around one corner as a pivot, and then around another corner to avoid disastrous contact with adjoining buildings. Instead of one revolving movement, it was therefore necessary to make seven separate movements, each requiring change of tackle and runway.

In this manner the task was accomplished in about ten days. It is interesting to note that by running the lead line of the tackle at an acute angle instead of tangent to the arc, the resultant force would swing the structure and at the same time push it back a considerable distance on the greased surface of the steel plates, thereby showing the absolute reliability of the temporary bracing.

When the turning movement was accomplished, the structure was lifted another 10 ft., to allow for the insertion of an additional stable floor. The ring floor as it now stands is about 12 ft. above the street level, with a two-story stable beneath. Before removing the skeleton box from around the old arches, steel columns on grillage and concrete foundation were placed under the old skewbacks and the whole structure was thoroughly and permanently braced.

The ring floor consists of the Metropolitan system of fireproofing supported on four 4-in. steel-pipe columns placed 4 ft. 8 in. apart north and south, and 9 ft. apart east and west. They serve not only as supports for the floors, but also as stall posts, and being placed at such short intervals prevent any vibration, which would otherwise result from the motion of such a large number of horses, as the present ring floor (107 x 180 ft., the largest in New York) will accommodate.

Mr. Bradford L. Gilbert was the architect, and Mr. C. O. Brown was the engineer in charge for the contractors.



Roof Trusses Braced Ready for Moving.

Submarine Drilling in the Clyde Near Glasgow.

By E. F Schaefer, M. M. E.

The conditions under which submarine rock excavation must be done are often extremely difficult, calling for special apparatus of unusual strength and endurance. Work of this character is nearly always carried on where currents and high winds are often present, and these elements are antagonistic to economical and rapid work. Until recently, indeed, they carried such uncertainty that it was a daring man who undertook river and harbor rock excavation. Owing to the increasing draft of both ocean and lake-going vessels the removal of subaqueous rock is daily becoming more important. The deepening of channels is possible only because of the improvements made in rock drills, and to-day such work may be done effectively, rapidly and cheaply. In modern submarine drilling, steels are used anywhere from 30 to 60 ft. in length and sometimes they weigh as much as 400 lb. To drill with such steel in hard homogeneous material is a tough problem. In poor material and under water where the drill must be run by the sense of feeling, difficulties are multiplying, as it is absolutely essential to have a drill which is at once massive, powerful, durable and capable of perfect control through all ranges of length of stroke and weight of blow. The drill must, of course, be mounted on a barge, scow or float, fitted with suitable framing to support the drill guides, the drills, the boilers and other auxiliary apparatus. The barge is towed into place and anchored by means of cables, anchor chains or spuds, or a combination of these methods, depending upon the rise and fall of the tides or the currents to be encountered.

Messrs. Hill & Co., of Plymouth and London, have recently taken a large contract for work of this character at Renfrew. The work to be accomplished is very extensive, and consists in drilling, blasting and removing rock for deepening the Clyde River. Many thousands of holes must be drilled, the average depth of each being about 8 ft. Occasionally, however, the bed of the river is such that a depth of 10 ft. is necessary, and this drilling must be accomplished through a maximum depth of water of 30 ft.

Each barge is provided with eight Ingersoll-Rand drills, each having a diameter of 5 in., and a stroke of 8 in. The drills take steam at 120 lb. pressure from two marine boilers on either end of the barge. They are connected to a main steam pipe which runs along behind the drills, from which branch pipes, fitted with stop valves, are taken. The drills are connected with these branch pipes by steam hose. Immediately below the stop valves are hand winches which are used to feed the drills to the work or to raise them from it. The drills are supported in guides and suspended by wire ropes which pass over pulleys at the top of the frame and under pulleys at the bottom, thus allowing a very accurate feeding of the machines. Behind these winches is a secondary and smaller winch provided with a wire rope to hoist the drill steels from the holes and replace them preparatory to drilling. The winches and the handles of the stop valves are in close proximity so that one man can handle each machine.

Submarine tubes used on this contract consist in each case of long lengths of 4-in. screwed piping which may be extended to meet the rise of the tide. These tubes are forced through the overlying mud, sand or gravel to the rock bed and serve to keep the advancing hole free from extraneous matter. The holes are drilled exactly as in the case of drilling down holes on land, the drill being fed down as far as possible, then run back, a longer steel inserted, and so on until the desired depth is reached, when the steel is removed and the hole charged with explosive through the tube. The casing tube is then removed, the wire connected with the blasting battery and the explosion effected without shifting the barge.

A further feature of the plant is the cages situated at either side of the drills permitting any adjustment to be made while the machines are in operation. From the time of starting the first drill to finishing the set of eight holes, the average time consumed is from 2 to 2½ hours. This work is so extensive in character that up to the present time nearly two years have been devoted to it, and before its completion there is a possibility of operation being continued for another year.

Electrical Production of Ozone.

The electrical production of ozone has been investigated by Prof. A. W. Ewell, who gives an account of his work and its results in the "Physical Review." The knowledge gained in this way has been used in designing an ozonizer which has shown very high efficiency during preliminary trials. The electrodes are straight, parallel nickel-plated wires, all in the same plane, alternate wires projecting on each side and being joined to the external electrode. Perpendicular to the plane of the wires and midway between each pair of them is a flat plate of dielectric, sufficiently wide to prevent discharge between the wires. The shape of the dielectric being the simplest possible, the danger from breakage is a minimum and the choice of dielectrics is greatly increased. Glass and fiber have proved very satisfactory, hard rubber is apparently acted on by the ozone, and mica gives an iregular discharge.

A Fatal Accident in a San Francisco sewer, due to the presence of foul air in a dead end, again calls attention to the necessity of care in entering such places unless it is known that they are properly ventilated. It sometimes happens that in old combined sewers an opportunity is afforded for foul air to collect, and anyone who enters such a pocket does so at the risk of death. In the San Francisco case a workman entered such a dead end in order to clean out a connecting sewer entering it. He was overcome by the gases and lost his life, and several men who entered the sewer to recover his body barely escaped. Such places in a sewerage system should not exist, but as they still remain in some cities effective precautions should be taken to prevent any such fatalities to the men who must work in them.

Reinforced Concrete Pipe Sewers in St. Joseph, Mo.

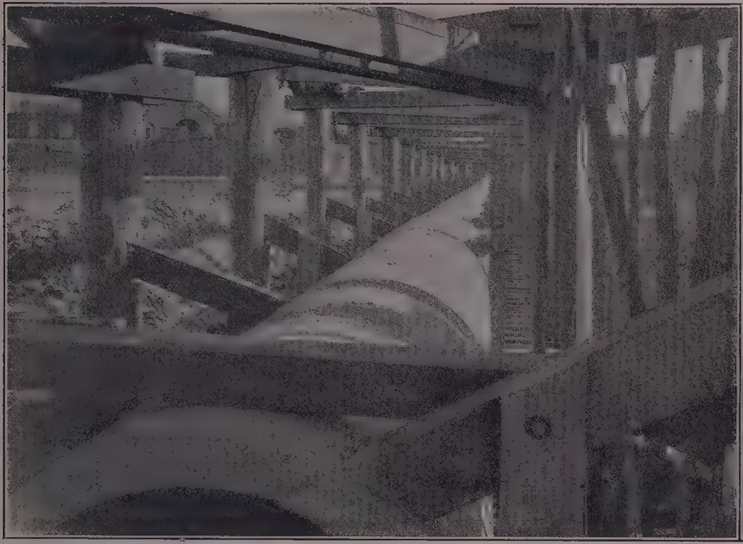
A harbor line has recently been established along the Missouri River front in St. Joseph, Mo., 175 to 375 ft. outside of the old main bank of the river. The Union Terminal R. R., of St. Joseph, is filling in this strip of land, which was 20 to 30 ft. below the river bank, for a distance of 5,300 ft., thus reclaiming about 35 acres. Several of the main sewers of the city discharged into the river at different points along the strip that is being filled, and had to be extended to the harbor line. The first work that was done in reclaiming the low land was to build a dike of piles along the harbor line and cross dikes from it to the shore. The dike on the harbor line consists of three rows of heavy timber piling in bents of three piles each, the bents being inclined upstream. The bents are heavily cross-braced and the whole dike is braced by top and bottom longitudinal stringers to each row of piles. The cross dikes are built of two rows of piles, similarly braced, the piles in the rows being staggered. The dikes were built to catch and deposit in the low area back of the harbor line some of the extremely large amount of silt carried by the river. More than 1,000,000 cu. yd. of material were deposited back of the harbor line in less than a year after the dikes were started in March, 1905. The remaining 900,000 cu. yd. necessary to complete the fill to 8 ft. above high water line is being deposited by centrifugal dredges, which pump sand from the river channel into the space surrounded by the dikes.

The cross dikes were built on the lines of the sewers which had to be extended across the area that is being reclaimed. Four of these sewers, a 36-in., a 42-in., a 48-in. and a 72-in., have been extended with reinforced-concrete pipe, built in 3-ft. sections on the river bank and then laid in place. The pipe was made by the Reinforced Concrete Pipe Co., of Jackson, Mich., and in order to be absolutely certain to secure good results the same company also took the contract for laying the pipe. The extensions were laid on transverse timbers carried by the lower longitudinal stringers on the rows of piles in the cross dikes. These transverse timbers are spaced 18 in. on centers, so each 3-ft. pipe section is supported at two points. At the time the extensions were made, the deposit of sand over the area enclosed by the dikes had not been raised to the timbers carrying the pipes, so the latter had to be carried entirely by the timber structure. As the current in the river has a velocity of at least 8 ft. a second during floods, even inside of the dikes, the pipes had to be built to withstand this current until the fill is made around them by the dredges with the sand from the river.

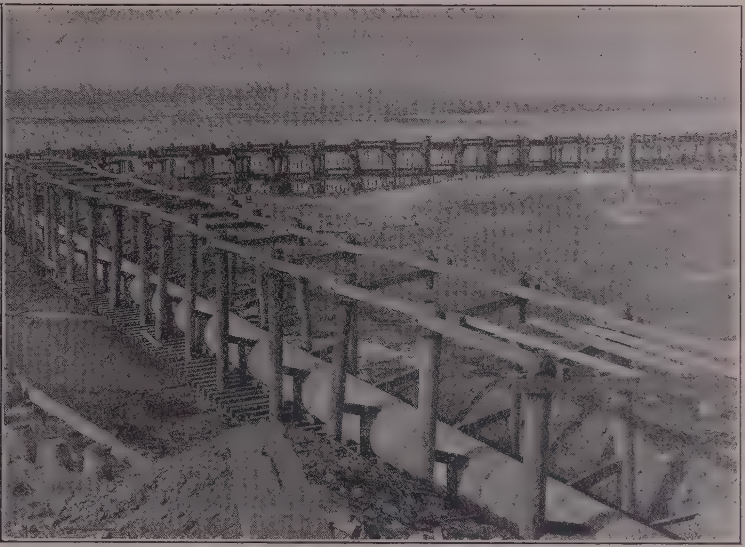
The extension had to be made during the winter and finished before the spring floods occurred in the river in order to avoid blocking the sewers with the silt which would be deposited back of the dikes during these floods. Tents were set up on the river bank as close as convenient to the land ends of the cross dikes on which the pipe extensions were made. The concrete was mixed and the pipe sections were made and cured in these tents, the temperature in the latter being maintained well above freezing by coke fires in salamanders. The pipes were all made in the regular forms of the Reinforced Concrete Pipe Co. The thickness of wall for the various sizes is 4 in. for the 36-in., 4½ in. for the 42-in., 5 in. for the 48-in, and 7 in. for the 72-in. pipe. Each pipe section is reinforced longitudinally by five bars, except the 72-in. pipe, which has seven longitudinal bars. Each section is also reinforced by two transverse circular bands, one placed 9 in. from each end of the section.

The thickness of one end of each section is reduced by a rectangular rebate, and by a beveled edge, both extending around the circumference. The other end is correspondingly flanged so that when the several sections are laid in position, the contact by entrance of one end to the other gives a smooth surface on the inside and leaves a uniform groove on the outside at the joints of the assembled sections. The longitudinal reinforcing bars in each section protrude with hooked ends into the rebated space which forms the outside groove when two sections are placed together in position. The sections are then interlocked by a tie-band which passes completely around the sections in the grooves at the joint and through the hooked ends of the longitudinal reinforcing bars. After the sections had been thus interlocked, the joint was girdled, except for some 20 in. on the top, with a galvanized iron shield. The outer surfaces were wet thoroughly, and the groove completely filled by pouring it with 1:2 Portland cement mortar, mixed with 25 per cent. water. The joint was protected from freezing immediately after pouring by a burlap wrapper filled with straw and manure.

In the process of manufacturing the pipe, a bottom plate of cast iron is used, shaped so as to give the flanged or receiving end of the pipe section. The core defining the inside diameter of the section is assembled in four sections of rolled sheet steel on the upper and inner flange of the cast-iron plate; the longitudinal reinforcing bars are inserted in receiving sockets in the plate and the outer case is then added on the lower and outer flange. The reinforcing bars are held in place at the top by space clips. The circular reinforcing bands are slot-punched, so as to receive and accommodate the longitudinal bars when the bands are put in place, as the process of making is followed. The concrete is shoveled into this form in very small quantities and the tamping is continuous, with the result that there are no layers or creases in the finished pipe. The concrete used in this work was composed of 1 part American Portland cement, 2 parts river sand, and 3 parts crushed limestone; the latter being a mixture of two grades, ranging from pea-size to 1 in. in diameter. The resulting concrete was exceptionally dense. Although the first pipe was made Dec. 26, last, and the sewage was turned into the extensions on Feb. 16, there has been no cracking or settlement of the extensions, nor has there been any leakage at the joints. The method of making and laying the reinforced-concrete pipe produces an unusually smooth and uniform cross-section with perfectly tight joints, as may be seen in the accompanying illustrations.



72-Inch Reinforced Concrete Pipe Sewer.



42-Inch Reinforced Concrete Pipe Sewer.

Mr. S. W. Fox, chief engineer of Union Terminal R. R. Co., of St. Joseph, Mo., made the plans for the reclamation of the area back of the harbor line and is supervising their execution. The Reinforced Concrete Pipe Co., of Jackson, Mich., not only took the contract for building the pipe, but also for laying it, with the exception of the 36-in. pipe, which was laid by the forces of the railroad company. Mr. Wm. H. Floyd, Jr., is city engineer of St. Joseph.

The Flaming Arc Lamp was rather late in securing a footing in this country, but is now receiving enough careful study by American electrical engineers to afford definite information before long concerning its place among our illuminating apparatus. Its brilliant light, yellow, white or pink, makes it an astonishing sight, even to those who have previously read about it, while its efficiency is equally surprising. It gives from five to ten times as much light per watt as the common enclosed arc lamp, and bids fair to become as cheap as any illuminant. At present it labors under the disadvantage of evolving such a quantity of fumes that its use indoors is unadvisable until some remedy for this condition is found. It must also be trimmed more often than the enclosed arc lamp, being on a par with the open arc in this respect.

The Administration View of Panama Canal Affairs.

Extracts from the statement of Secretary Taft before the Senate Committee on Interoceanic Canals.

Labor.—With deference to the opinion of men much more experienced in the matter than I, I venture to say that we shall have to build the canal with tropical negro labor, expensive as it is. It may be that we shall secure Spaniards or other white men who are able to withstand the tropical sun, but at present I see but little prospect of it.

Chinamen do not make better laborers than other people when imported without their bosses or No. 1 men who have absolute control over them. They have been tried on the Isthmus before, and showed themselves quite subject to disease and also to discouragement leading to suicide. The negro labor of the West Indies is inexhaustible so far as our demands go, and it seems to me that we must rely on training them, eliminating the poor and rewarding the more industrious and competent. I do not think that Mr. Shonts and Mr. Stevens agree with me in this, and I am quite willing to follow them in any experiment within the law which will lead to a different result from that I anticipate.

Contracts.—Of course the canal ought to be built by contract if it can be so built, and I think every one who knows about the situation believes that ultimately it will be possible in the interests of the Government to make proper contracts; but I beg the committee in the discussion of this subject to bear in mind that at present it is utterly impossible to frame a law which shall be of any assistance in furthering the construction of the canal by contract. The Government is bound to proceed with construction for some time in order that it may itself learn the cost of doing work under the conditions that exist on the Isthmus, and in order that contractors may learn from actual conditions the prices which they can afford to bid for the work to be done. Mr. Stevens told me that he thought it might require a year before all the plans and specifications for the work could be concluded.

He is now almost ready to begin work on the construction of the canal as soon as its type is determined, and the making of plans and specifications would not interfere with his proceeding upon the work, which does not need the completion of plans and specifications to begin and to continue it.

Certainly a year, and probably more, must elapse before the time arrives in which invitations for bids should be prepared, and then six months or even longer time should be given, in order that possible bidders may have the opportunity to examine the Isthmus and make sure of the work they will have to do. If bids were opened now, bidders would be in the dark, and the result would be much higher prices because of the large element of risk due to lack of knowledge which would enter into the fixing of every bid, and thereby increase it largely. There is not the slightest disposition on the part of anyone for the Government itself to build the canal. It will be much better to have the Government make the contracts and then use the chief engineer and such subordinates as may be necessary to supervise the work and see that the contracts are properly performed and their terms complied with. But there are many difficult questions to be settled as to the way in which such contracts ought to be let, whether the work ought to be divided, or whether the contract ought to be let as a whole. The Government would of course rent its plant to the successful bidder, and probably would have to turn over the railroad to him to run, complying with the charter as to commercial business. The necessity for the use of the railroad in the construction of the canal and doing the work which will have to be done by contract may lead to a unit contract, for it is difficult to see how different contractors spread along the axis of the canal route could all control and make use of the railroad without confusion and conflict.

The Old Commission.—The Commission which was appointed on the 3d of March, 1904, with Admiral Walker at its head, did a great deal of very hard work. It was composed of able and honest men, and in certain directions it secured admirable results. Messrs. Burr, Parsons, Grunsky, and Harrod were excellent engineers, and were well adapted to direct the engineering surveys which were projected and begun before a chief engineer was appointed. General Davis, although not by profession an engineer, is nevertheless much better qualified to speak on engineering subjects than most engineers.

General Davis was an admirable man for the organization of the government of the zone—painstaking, hard-working, clear-headed, economical, courageous, and loyal. He was generally absent from the deliberations of the Commission, which usually met at Washington, and he exercised no authority on the Isthmus other than as governor and supervisor of the sanitation measures. He is not, therefore, to be held responsible for such shortcomings of the Commission as may appear.

Admiral Walker had had a great deal of experience in the investigation of both the Nicaraguan and the Panama canals, knew the Isthmus well, and had been an able naval officer. In the selection of the chief engineer, and in the organization of the government of the Zone and the preliminary engineering work, in the organization of the sanitary force, the selection of the chief sanitary officer, in the enactment of the laws for the Zone, the Commission showed itself well adapted to the work which lay before it.

The old Commission organized the sanitary department under Colonel Gorgas, and it is entitled to credit for the success which has attended Colonel Gorgas's efforts, although of course Colonel Gorgas himself is the chief agent in having brought this about. I have been at times inclined to doubt whether the Colonel's plan were best adapted to the speedy sanitation of the Isthmus, and whether he had the executive ability which would lead to satisfactory results; but I am entirely willing to admit that he has vindicated his theories and has carried them to a logical conclusion and has wrought a wonderful change in the health conditions on the Isthmus.

The Commission also began under Mr. Wallace the work of reconstructing the old French houses in which it is intended that the employes and laborers shall live and had reconstructed about 350 out of 2,100 when Mr. Wallace left. They constructed a hotel at Corizal and a hotel at Culebra, and they projected and almost completed before they were retired the water supply for the city of Panama, and for many of the other towns in the Zone. They attempted to secure the needed employes to make the working force on the Isthmus. The application of the civil service law in a modified form and their reliance on the Civil Service Commission to furnish employes did not result fortunately. The truth is that neither the Washington bureau of the Commission nor the Civil Service Commission was able to furnish the skilled workmen and "outside" employes that were required. The Civil Service Commission did not have eligibles of the kind needed or machinery to secure them. This country was prosperous, most people who would have been useful on the Isthmus had employment, and it was difficult to secure the kind of men who were wanted. Mr. Wallace complained greatly of the incompetency of the men who were sent to him, and I am bound to say that his complaints were well founded. I do not think that in this respect the Commission met the situation. The application of the civil service law could have been modified to meet the exigencies, as it has been since. It would have been better if they had sent out competent, professional employers of labor to secure the proper men, as the new Commission has since done. As the work expanded and the demand for men grew greater, the defect of its organization in this respect became more apparent.

The work of excavation which was done by Mr. Wallace under the old Commission at Culebra was carried on largely for the purpose of experiment. I do not feel competent to pass judgment on the wisdom of what was done there. The use of the Belgian engines and the French tracks and the small cars and the old French dumps, which were not well placed, and the lack of the element of the long haul, which will probably enter largely into the cost of most of the excavation, created such a difference between the experimental and the actual conditions to be met that I am inclined to think that the data obtained are not very valuable and that the time and attention spent might better have been put on the construction of houses and the sanitary construction work of which there was so much needed. But I venture this opinion with great hesitation and with deference to the judgment of Mr. Wallace and the professional engineers of the old Commission. Certainly the excavation of 700,000 cu. yd. is an excavation that will not have to be done again.

Delays in Forwarding Supplies.—The chief defect of the old Commission, if I may say so, became apparent when it essayed the tremendous executive task of perfecting an organization to furnish the equipment, the material, and the supplies required in increasing quantity on the Isthmus as the work expanded, with promptness and dispatch. This was a complaint which Mr. Wallace might most justly make and which he did make. It was one of the chief obstacles in the performance of his task.

I do not mean to say that under any circumstances and under any management the opening of the canal project and the ordering of equipment, supplies and construction material at such a long distance would not have been attended with exasperating delays, but it is quite apparent that the methods of the Commission for this purpose were not businesslike, expeditious or systematic.

The purchasing department was conducted by Mr. Redfern, who was a secretary or clerk in the office with but little previous experience as a purchasing agent. While he was a hard and faithful worker and did all he could, he was swamped with the requisitions which came to him; so that on Feb. 1, 1905, when Major Gallagher took hold he found a great number of requisitions in the office of the Commission that had not even been opened.

General Davis, when I was on the Isthmus, pointed out instance after instance in which he had submitted matters to the Commission for decision which were delayed so long that he could not understand it. I sent an inspector from the Surgeon-General's department to Panama for the purpose of making a report upon the sanitary measures begun and carried on there. I directed that he report to General Davis, to Colonel Gorgas, and to the chief engineer, but that he exhibit his instructions to no one else. In his report Major Mason states that the principal large requisition for medicine and medical supplies was made about Aug. 1, 1904, and at the date at which he wrote (Feb. 8, 1905) not one item had been received, and that other large requisitions had met the same fate, and that Governor Davis told him that these requisitions were approved by him and went forward promptly, and that he had done all in his power to get them filled, and what the trouble was he did not know. Meantime, he said, he had bought what was most urgently needed through the local markets, and even articles purchased in the local market had sometimes required nearly, or quite, a month for delivery.

The body of seven Commissioners, with each one an executive, was not well adapted to the growing work. Admiral Walker frequently said to me in the trip which we took to the Isthmus in December, 1904, that some change must be made in the organization of the Commission if the proper results were to be obtained. I think that the admiral felt that if he had the executive power himself he could meet the situation, but that with a clumsy body of seven constantly called upon to exercise executive functions as a unit rapid and efficient action was most difficult to obtain.

Colonel Hecker resigned Nov. 16, 1904, and it was understood at the time from Colonel Hecker that the chief reason for his withdrawal was his feeling that under the present organization the Commission was not likely to accomplish well the purpose for which it was created and appointed.

Mr. Parsons and Prof. Burr visited the Isthmus in February and March, 1905, and on their return Mr. Parsons advised me of his intention to resign from the Commission on the ground that it was not so organized as to make executive work by it successful. He expressed himself in the same way to the President. He sent to me a plan of reorganization which he regarded as one which would work.

General Davis under date of Jan. 6, 1905, wrote me as follows:

"The newspapers have stated that in the special report which you have recently submitted to the President a recommendation is contained for a reduction of the number of members of the Isthmian Canal Commission. I hope the report is true, for I am satisfied that the present body is far and away too cumbersome and ineffective."

The New Commission.—In reorganizing the Commission we attempted to follow the suggestions of Mr. Wallace, Mr. William Barclay Parsons and General Davis. I append the letters and memoranda of Mr. Wallace, Mr. Parsons and General Davis on this subject.

The order of April 1 specified the duties of the chairman of the Commission, and the other members of the Commission, made the chief engineer a member of the Commission, and the governor of the Zone a member of the Commission, and constituted them an executive committee with power to act. The remaining four were engineers, and were paid a considerably less salary than those which were provided for the chairman of the Commission, the chief engineer, and the governor of the Zone; or, to put it in another way, the salary of each member of the Commission was fixed at $7,500, and the chairman received in addition to that as chairman $22,500, the chief engineer received $17,500 additional, and the governor of the Zone $10,000 additional.

The result of the operations under the old Commission convinced me and convinced the President that it was absolutely essential to have a completely new organization in Washington for the purchase and forwarding of supplies, machinery and construction material, and also for the procurement of the needed employes. In other words, it was essential that this work should be attended to by someone who had large experience in the construction of railroads or other important work, and who understood the methods by which the parts of the organization were assembled and made effective. A number of candidates were selected, and after a careful investigation, the President concluded that Mr. Shonts filled the requirements of the position in a most satisfactory way.

I do not hesitate to say that one great difference between the work of the old Commission and of the new is due to Mr. Shonts' experience and energy in effecting and maintaining an organization for the purpose of selecting employes, making proper contracts for the purchase of needed machinery and material, pushing forward the transportation of such equipment and supplies and for instituting a proper system of accounts and records.

The whole office of the Commission in Washington was reorganized. Mr. Benson, an auditor of long experience in railroads, was made the general auditor of the Commission; Mr. David W. Ross, one of the ablest railroad purchasing agents in the United States, was employed to reorganize the purchasing department, and the selection of employes was placed under Mr. Pepperman, who had large experience in civil service, both in this country and in the Philippines.

The organization has, on the whole, worked very well. When Mr. Stevens succeeded Mr. Wallace he was not made a member of the Commission, so that the executive committee now consists only of Mr. Shonts and Governor Magoon. This would have been inconvenient but for the presence of the four engineer members of the Commission in Washington, where Mr. Shonts has been; so that it was possible to do all necessary business through the Commission instead of an executive committee.

The order contemplated the presence of Mr. Shonts on the Isthmus six months in the year, but it has been absolutely impossible for him to be as much on the Isthmus as was contemplated when the order was made. The organization of the bureaus here, the purchase of material, and the calls for his presence in view of the investigations by appropriation committees and this committee have made it entirely out of the question that he should be on the Isthmus half his time. He has done extraordinarily good work in bringing about the organization at this end, and it has been work which has effected great results upon the Isthmus.

Secretary Taft's Conclusions.—Had our foresight been as clear and wise as our retrospect may now be comprehensive and detailed, we migh have avoided a number of mistakes. We have taken about two years to make the preparations necessary to begin the work of excavation. Those preparations have involved a great deal of preliminary construction and a great deal of persistent effort to make the Isthmus a healthy place in which our officers, employes, and laborers may live and work. There have been a great many difficulties to overcome in effecting a proper organization. As this is a governmental work and as every member of the public is entitled to know how it progresses, it has been subjected to a great deal of criticism, both just and unjust. It is impossible to compare the number of mistakes made in such preparation and organization with the number of mistakes that would have been made under private organization, for the reason that private corporate organization is not subjected to the fierce light that beats on a Government enterprise. The agents of a corporation are not held up to public obloquy by writers in the public press who can make but partial investigation into the facts and are consciously or unconsciously anxious to exaggerate and make sensational the faults of public servants. This one circumstance of the injustice and unfairness of public criticism through the press creates reluctance on the part of competent men to accept positions of responsibility in such an enterprise. In spite, however, of all the difficulties, I feel confident, from the reports which come to me, that everything on the Isthmus under the most efficient administration of Mr. Shonts, Governor Magoon, and, most of all, Mr. Stevens, is in a condition that ought to commend itself to your committee. The enterprise is now organized on business principles, and it is about time for the work of construction to begin. He would be a rash man who would assert positively and unequivocally that there had not been any waste of money or any corruption of any kind in the expenditure of some seventeen or eighteen millions under the conditions of distance and the sometimes necessary freedom from the closest supervision that have obtained in this work, but it can be affirmed that in spite of all the investigations, in spite of all the publicity given in various papers, as yet there has been no proof of corruption of any sort in the enterprise since the beginning, and I certainly hope that there is and will be nothing to justify such proof.

Selection of Employes.—The following statement was prepared by Mr. W. Leon Pepperman: Prior to Nov. 15, 1904, employes of the Isthmian Canal Commission were in no sense subject to civil service requirements. They were selected by the Canal Commission in such manner as that Commission saw fit. It was understood, however, that the practice was to accept and file applications, and, upon the need of employes, to select from such applications the persons deemed best qualified.

Second. On Nov. 15, 1904, the President issued an order placing the employes of the Canal Commission in the classified service. The Civil Service Commission was necessarily unable to immediately establish eligible lists for the various positions, and until the Canal Commission was formally notified of the establishment of an eligible list for a particular position it was authorized to follow the old method in selecting employes for that position. Furthermore, after establishing an eligible list for a particular position in the first instance, when that eligible list became exhausted the Canal Commission was also authorized to select its employes under the old procedure. Pursuant to authority contained in the foregoing instance, the Canal Commission did continue the method of selecting from applications placed on file.

Third. Following the reorganization of the Canal Commission in the spring of 1905, the demand for employes on the Isthmus materially increased, and the practice grew up of authorizing subordinate officials, while on leave of absence in the United States, to select their subordinates. In addition, Captain King, who had charge of personnel under Engineer Wallace, accompanied that official to the States, and remained in Washington about six weeks following the reorganization. During this period he selected a large number of all classes of workmen. These subordinate officials from the Isthmus selected their employes, under authority of the Civil Service Commission, for those positions for which that Commission either had not yet established eligible lists in the first instance or the eligible lists for which had become exhausted. To supplement the labors of these subordinate officials on leave, and with the approval of the Isthmian authorities, a practice grew up of allowing a subordinate official newly appointed to select employes of a character which would probably be under his supervision when he assumed his duties on the Isthmus, to accompany him down there.

Fifth. The method outlined in the preceding paragraph was subject to two vital objections: First, the uncertainty as to whether or not the Civil Service Commission had an eligible list, or would have an eligible list available, and the further fact that by giving authority to so many different persons to select employes there was great danger of applicants being misadvised as to the true conditions of employment; therefore, under agreement with the Civil Service Commission in the late summer of 1905, permanent employment agents were placed in the field in the United States. These agents were to be charged only with the securing of the mechanical trades and building trades people and the outdoor railroad positions. The eligible lists of the Civil Service Commission for such employes were to be done away with. The employment agents were to be made members of the local civil service boards throughout the country, and a system of ratings based on the elements of age, experience and physical condition by such employment agents as members of such boards was to satisfy the civil service requirements.

Sixth. The divided responsibility as imposed in the preceding paragraph proved unsatisfactory, and ultimately resulted in a clean-cut division of employes into two classes—those to be selected by the Civil Service Commission and those to be selected by the Canal Commission in such manner as it saw fit. This was accomplished by the President's order of Jan. 12, 1906, under the provisions of which clerks of all kinds, bookkeepers, stenographers, typewriters, surgeons, physicians, internes, trained nurses and draftsmen were to be selected from the civil service lists.

Following this three employment agents, representing the chief engineer and selected by him, were placed in the field. Requisitions for personnel are made direct upon the Washington office, which utilizes these three employment agents stationed in different parts of the country in rounding up properly qualified persons for isthmian service. A fixed wage scale has been adopted, and if the employment is an unusual one not provided for in such wage scale the salary is set forth in the requisition calling for such employe. Employes are selected strictly in accordance with requisitions and sent to the Isthmus according to prearranged schedule. The system is working satisfactorily.

Mr. Wallace's Recommendations Regarding Organization of Commission.—If a personal recommendation as to the constitution and assignment to duties of the Isthmian Canal Commission is at all permissible, the following suggestions are made:

It would seem evident that satisfactory results cannot be obtained in a speedy and economical construction of the Panama Canal through a commission of seven men exercising executive function. While in a multitude of counsel there is undoubtedly wisdom, proper executive action cannot be secured through such a medium; and while it may be impracticable to change the form of the present Commission as established under the Spooner Act, it could be kept intact and its functions so modified as to secure the benefit of the advice and counsel of its members without such weakening of the executive function as now exists, the administrative and executive control of the work on the Isthmus being placed in the hands of the chief engineer, as per his suggestion and understanding with the Commission at the time of his engagement.

The chief engineer should be given as free a hand as possible consistent with a proper control of the work in accordance with existing laws and with sound business principles. This is particularly necessary when the fact is considered that this work is to be conducted in a tropical climate 2,000 miles away from the seat of government, and is an undertaking requiring prompt executive action by the chief engineer situated on the grounds.

In this connection it is suggested that the functions of the four members of the Commission who are civil engineers be confined to the technical study and consideration of such general plans as may be submitted by the chief engineer, or such additional plans as may be called for by the Commission; that they act in a consulting and advisory capacity, and that these gentlemen be not burdened with matters of detail in elaboration of these plans or in their execution, which should be left with the chief engineer and his staff. While they should make such visits to the Isthmus as will enable them to keep in touch with the progress of the work and give them a prior knowledge of the general situation, it should not be necessary that any of them should permanently or regularly reside on the Isthmus.

It is evident that the general business of the Commission connected with the governmental departments and the general public, as well as the supervision of the securing of material, must be conducted at the seat of government. As the work progresses, the securing of the necessary material upon requisitions of the chief engineer, the letting of contracts, and other proper business matters of a general nature would prove to be a very important factor in the successful conduct of the work.

It is suggested that, with the chairman having general charge of the executive functions of the Commission, the routine work be divided as follows:

(1) One member of the Commission acting as a committee on purchase of materials and supplies, to be assisted by a first-class competent business man as purchasing agent, supported by a clerical staff competent and sufficient to properly look after all matters connected with purchases and the letting of contracts for materials and supplies.

(2) One member of the Commission acting as a committee to have charge of the shipment, general custody and care of material and supplies after purchase, collaborating with the chief engineer in the supervision and inspection thereof, assisted by the chief of material and supplies department on the Isthmus. This latter department, however, should be under the chief engineer and subject to his direction and control as far as the care, distribution and use of material on the Isthmus is concerned.

(3) One member of the Commission, acting as a committee, to have supervision over appointment and the securing of such labor as it may be necessary to engage in the States, collaborating with the chief engineer in this respect. He should not, however, have arbitrary control over appointments, but rather should assist the chief engineer in his selections.

(4) Three members of the Commission, who are civil engineers, acting as a committee, to pass on the general features of all plans, giving its time to the consideration of the larger engineering problems, but whose functions should cease after reporting to the Commission in favor of or against, or recommending modifications of, the various plans recommended by the chief engineer.

This committee should also be charged with investigations of such questions as the chief engineer may submit to it for advice and counsel. It should not, however, be burdened with the consideration of detailed plans or with the execution of same after their final adoption by the Commission. The plans adopted by the Commission should only be general, as the chief engineer should have authority to make necessary changes as to details, so as not to be unduly hampered should contingencies arise in the conduct of the work the submission of which to the Commission would delay its progress.

Mr. Parsons' Suggestions.—The law provides a commission of seven members, of whom one shall be an army officer, one a navy officer, two engineers from civil life, and three to be chosen without restriction. It is essential for success that the executive functions should be restricted to as few men as possible, and that no one should have executive functions except as coupled with specific duties of high order. There are three such positions, viz., chairman, governor and chief engineer. Cannot advantage be taken of the requirements of the act which divides the Commission into two parts, professional and non-professional, and differentiate between their duties, functions, powers and compensation?

Assuming that it is your intention, as you have stated, to make changes in the office of chairman and governor, the realization is simple. Appoint a good business or corporation man as chairman and a lawyer as governor, and the chief engineer a member of the Commission, those three, and those three only, being charged with full functions, including the power of legislation. Give these men a suitable salary of fixed amount within per diem extras. The other four Commissioners, consisting of the two military officers and two engineers, to form an engineering board. These Commissioners, with the chief engineer, to decide upon the type of canal, upon its dimensions, and from time to time upon the various plans for major details, and to act as an advisory board to the chief engineer to pass upon such questions as he may refer to it. These latter Commissioners would not be expected to reside in Washington or on the Isthmus, nor would they be expected to give their whole time to the work, but only as needed. Their compensation might be made $5,000 or $6,000, with a per diem allowance and all traveling expenses when absent from the United States.

This is substantially your own scheme, except utilizing the present law. The differentiation in powers could be openly stated in a letter of appointment by the President. It makes a small working body with definite duties for each Commission. A resident Commissioner, either on the Isthmus or in Washington, without specific and engrossing functions, it to be avoided at all costs.

General Davis' Suggestions.—The newspapers have stated that in the special report which you have recently submitted to the President a recommendation is contained for a reduction of the number of members of the Isthmian Canal Commission. I hope the report is true, for I am satisfied that the present body is far and away too cumbersome and ineffective.

It has been suggested as a possibility, or even a probability, that in the new legislation that Congress may enact the governor of the Zone would be divorced from the Commission, and that the person holding the office of governor would have no connection with the Canal Commission. I hope that the legislation will not take this shape. Instead, the governor—a member of the Commission—should also be the American minister to the Republic. A secretary of legation and a clerk, with allowance for an office and stationery from the State Department, is all that would be required.

Two days ago I received a copy of the minutes of the proceedings of the Isthmian Canal Commission, covering the period from Sept. 7, 1904 —when the Commission left here—up to Dec. 15, 1904. The records sent to me were those for the thirteen meetings that had taken place in that interval, not a word of which had been previously forwarded to me, and were not received until after I had protested against the neglect.

I observe by the proceedings that the Commission has adopted something slightly resembling the recommendation which I made and on which I asked for a vote on Aug. 31, that looked to the appointment of an executive committee to be permanently resident here, with power to act.

The new plan contemplates a visit to the Isthmus from time to time of the standing committees of the Commission, one at a time. There are five of these committees, each consisting of two members, and when such standing committee of two visits the Isthmus the governor of the Canal Zone is to be ex-officio a member of the committee then present; but I cannot find from the records of the action taken that any authority to act, or that any power of direction, is to be vested in such local visiting committee. Whenever the two members visit the Isthmus it will be for observation only, to report back to Washington. Questions are arising here constantly with the chief engineer, the chief of materials, the disbursing officer, and with the governor, all of which must be submitted for the action of the Commission in Washington, and all of them ought to be disposed of on the spot. The governor and the two visiting members will not make a quorum, and so nothing can be disposed of, for all these questions will have to go up as before.

Only when more than three members visit the Isthmus can there be a quorum present, and as the recent resolutions that have been adopted make no provision for the visit of the larger number, it necessarily results that one member of the Commission, who is permanently a resident of the Isthmus, will never be able to meet with his colleagues and sit as a member of the Commission.

This resident member of the Commission is also a member of the board of directors of the Panama R. R., but as this board always holds its meetings in New York the Panama member will never be able to take any part in the business of the board of which he is a member, unless the board meets on the Isthmus, as I contend it ought to do, save as respects the stockholders' annual meeting.

If the present Commission should be abolished, and the whole direction, control and supervision should be turned over to the Secretary of War, I would say that the best organization would be a commission of three, their headquarters here, and the general counsel here also. I am more and more convinced every day that the home for the Isthmian Canal Commission should be on the Isthmus, as is the home of the Philippine Commission in the Philippines. A commission of three or five—the chief engineer one of the number—would be a much better working board than a larger number; and a quorum never absent. There should be a purchasing agent and a disbursing officer of the Commission somewhere at home, but I see no reason for any other office of the Commission in the United States, and if the whole work—everything devolved upon the Commission—were turned over to the War Department, the purchases and forwarding of supplies and persons would go on without a hitch. One of the members should be an officer of the Corps of Army Engineers. I regard Mr. Wallace as a very superior man, and he ought to be retained.

THE IMPROVEMENTS IN RECORDING PYROMETERS that have been made lately afford a convenient means to boiler-plant owners of maintaining a constant oversight of the temperatures of flue gases. While it is true that a boiler plant may be working poorly and still show a low flue temperature, the chances are very largely in favor of bad operation being attended by high temperatures. Types of instruments of this nature are now made which are as simple to read as a voltmeter, and the information they furnish in any large plant will probably enable an annual saving of fuel to be made amounting to many times the cost of installing them.

Book Notes.

A second edition of the "Text-Book of Marine Engineering," by Engineer-Commander A. E. Tomkins, R. N., has appeared, in which there are many indications of rewriting and additions in order to bring the text strictly up to date. The author has wisely retained his former conservative position of avoiding expressions of opinion on unimportant disputed subjects, and devotes all his attention to an explanation of the mechanical equipment of a ship and its management. Boilers and their accessories, furnaces, stoking, engines and their details, shafts, ship resistance, propellers, condensers, pumps, piping, feed-water heaters and the other parts of the mechanical organism are clearly described with the assistance of numerous good illustrations. In only one respect are these drawings obsolete; the illustration of destroyer engines with inclined cylinders does not show a type of design which is regarded with favor at present. Anyone who desires a thoroughly good descriptive book on this important subject, free from mathematical formulas but containing practical information of a reliable nature, cannot do better than examine Commander Tomkins' work. (Portsmouth, Eng.; 12s. 6d.)

A new edition of Mr. Henry Davey's "Principles, Construction and Application of Pumping Machinery" has been published at 21s. by Chas. Griffin & Co., London. The high position of the author as a pump specialist and the practical nature of the information he gives make the volume a standard treatise. He traces the development of pumping machinery from its early days, describes the theory of the steam end as used in pumping engines and gives the results of numerous tests of such machines. Many types of water ends and valves are illustrated, their principles explained and some interesting displacement diagrams are furnished. The discussion of non-rotative pumping engines occupies three chapters and contains a large amount of information about the Cornish type, which might well be condensed in view of the present lack of interest in such engines. The author also explains the methods followed in sinking shafts in Great Britain and describes hydraulic and electrical methods of transmitting power to underground pumps. Valve gears for pumping engines have a chapter to themselves and so do hydraulic pressure engines. The author's system of well pumps is explained and the works of this nature at Widnes are described. While the information is based on British practice, the book contains a large amount of practical data useful everywhere.

The final report on the tests of coals, lignites and other fuels at the World's Fair station of the United States Geological Survey has been published in three volumes, containing a large amount of information. Congress appropriated $60,000 for the work, and a number of manufacturers helped on the investigations by furnishing apparatus at no expense to the Survey, or a very small one. The construction and operation of the plant were assigned by Director Walcott to Messrs. Edward W. Parker, Joseph A. Holmes and Marius R. Campbell. The first volume begins with an explanation of the manner of collecting the samples, which is followed by a discussion of the classification of coals; these portions were written by Mr. Campbell. The remainder of the volume is a description by Mr. N. W. Lord, of the chemical work done during the investigations. The second volume, by Prof. L. P. Breckenridge, is a report of the boiler tests. The data are reported in the form recommended by the American Society of Mechanical Engineers and cover a great variety of coals, although the limited testing facilities did not afford an opportunity for investigating the individual samples in furnaces of widely different character. The third volume contains reports on producer gas tests by Prof. R. H. Fernald, on coking tests by Mr. F. W. Stammler, on foundry tests of coke by Dr. Richard Moldenke, on briquetting tests by Dr. Joseph Hyde Pratt and on washing tests by Mr. John D. Wick. It is held by the committee in charge of the investigations that the producer gas tests were probably more important than any other feature of the work. They estimate that the power developed by small units from a number of bituminous coals, when converted into gas and used in an internal combustion engine, was 2.6 times that furnished by using them under boilers. The value of lignite in producers was likewise a matter of surprise. The coking tests were made in three standard beehive ovens and showed that many coals classed as non-coking may become coking by careful manipulation and their quality may be improved by adding pitch or a small percentage of coking coal. The briquetting tests are particularly valuable as indicating what may be done with a great variety of American anthracite and bituminous coals and lignites.

The importance of teaching branches of applied science by the quantitative method has only recently been properly appreciated in this country. Under the old system of qualitative teaching, the student was given a smattering of science, but when confronted with an actual problem he discovered that he knew nothing about the methods of putting his generalities into use in solving it. Accordingly he grew to underrate the true value of the instruction he had received and probably made up his mind that his sons should not be permitted to waste their time over such useless studies. Because the educational system under which he was "finished" was lop-sided he took a lop-sided view of all technical education. At the present time attempts are being made everywhere along the line of applied science to secure definite information so that the data obtained by experiment and theory can be employed in calculating what will take place when some new thing is done. An admirable example of the new type of quantitative text-book is Dr. Joseph W. Richards' "Metallurgical Calculations," which has been running in the "Electrochemical and Metallurgical Industry" and is now published in a thin volume, to be succeeded by two more parts at a later date. The mastery of the problems and their working principles presented in this book is equivalent to the mastery of the portion of metallurgical theory covered by them and will lead to a strong grasp of the subject. The only thing that can safely replace rule of thumb methods are calculations based on the results of careful experiments guided by sound theory. The book first explains the chemical equation. Atomic and relative weights, the relative volume of gases, exact weights and volumes, the weights and volumes of gases, and the corrections for temperature, pressure and the combination of the two are explained as elements to be considered in solving such problems as arise in the combustion of coal, combustion of natural gas and oxidation in a Bessemer converter. The author next takes up in the same way thermochemical nomenclature and data, and gives valuable tables of the heat of formation of oxides, hydrates and many other compounds. In the third chapter Dr. Richards takes up the use of thermochemical data; simple and complex combinations are explained, double decompositions are discussed, and there are some very interesting pages devoted to the calorific power of fuels and the theoretical temperature of combustion. Such special problems as the temperature of the Eldred combustion process and the thermit process are given enough attention to enable the reader to decide any general questions concerning them. In the fourth chapter the author takes up the thermochemistry of high temperatures and illustrates by examples some of the many interesting practical suggestions which thermochemical computations will afford when properly made. The thermophysics of chemical compounds next receive attention and there are useful tables. The last three chapters will probably prove most interesting to the readers of this journal, for they discuss artificial furnace gas, chimney and forced draft, and the conduction and radiation of heat. One of the problems which is worked through in detail relates to the utilization of waste heat, and as this is a subject which is interesting a good many engineers and shop managers at the present time, it is not at all unlikely that the few pages of the book devoted to it will be worth more than the $2 charged for the volume by the publishers, the McGraw Publishing Co., New York.

Letters to the Editor.

FORMULAS FOR CONCRETE BEAMS.

SIR: I have read with much interest a discussion of formulas for concrete beams by Mr. Goldmark, which appeared in your issue of March 31. This paper shows clearly the basis on which the principal formulas are built and very much simplifies them by a uniform notation throughout. It is unfortunate, however, that the paper is marred by some typographical errors, which I desire to point out, as follows:

Page 421, first column. In first line for y read y_2. In the equation in the middle of the column, for my read my_1. Toward the bottom of the column, in the first value for M_0, for $\frac{ST}{3}y_2$ read $3STy_2$, and in the third equation for M_0, for y_1^3 read by_1^3.

Page 421, second column. The quantity (Se/b) under the radical sign should be squared.

Page 421, third column. In the last line, for $tx = Tp$ read $tx + Tp$.

Page 422, first column. In the second value for M_0, $(4x/6)$ should be $(4+x) \div 6$. In formula (B), 15 Cby_1 should be 75 Cby_1.

Page 422, first column. In Hatt's formula $(1-x)$ and x should be interchanged in every case, if hx is the distance from the bottom of the beam to the neutral axis, as in Considère's formula. If, however, hx is the distance from the top of the beam to the neutral axis, then $(1-x)$ and x are correctly used, but the distance of the steel from the neurtal axis becomes h $(1-x-u)$ and $(u-x)$ must be changed to $(1-u-x)$ in all cases.

Page 422, second column, fourth line. On the latter supposition just stated, the value of M_0 (note that the sign of equality has been omitted after M_0) must be modified by substituting $(1-u-x)$ for $(u-x)$ in the numerator of the last fraction.

Page 422, third column. Equation (D) should read $M_0 = \frac{5}{8} Cbd^2(1-\frac{2}{5}x)x$.

It might simplify the working out of the various formulas, to take the general formulas and work out all the modifications that can be deduced from them, and then apply them as desired. Thus from equations (4), (5) and (6), which contain seven variables, S, T, C, b, d, y_1 and M_0, and three constants, n, m and c, the following may be deduced:

$$y_1 = \sqrt{\frac{Sed}{bn} + \left(\frac{Se}{2bn}\right)^2} - \frac{Se}{2bn} \qquad (7)$$

$$S = nbd \div (T/C+[T^2/eC^2]) \qquad (8)$$

$$M_0 = T(nmby_1^3/ey_2+Sy_2) \qquad (9)$$

If $p = S/bd$, we obtain from equation (7)

$$y_1 = d \sqrt{\frac{pe}{n}\left(1 + \frac{pe}{4n}\right)} - \frac{ped}{2n} \qquad (10)$$

The values of y_1 for various values of p are given by the curves in the accompanying diagram.

From equation (8) we get

$$p = n \div [T/C + T^2/eC^2] \qquad (11)$$

Goldmark's formula (A) and (C) may be derived directly from equations (10) and (11). Thacher's formula for M_0 is from equation (9), von Emperger's formula for y_1 is from equation (10).

From equation (11) we see that for any given beam (since n, m and e are assumed as constants) if we wish the concrete and steel to reach given unit stresses C and T at the same time, there is only one percentage of steel that will satisfy the condition. Equation (6) shows that, for the same unit stresses, the position of the neutral axis is fixed. Hence the position of the neutral axis is determined by the percentage of steel, as also appears from equation (10). There is the question of economy to consider in deciding on the percentage of steel to use. It would appear that it is not economical to use a small percentage of steel of high elastic limit, stressed high.

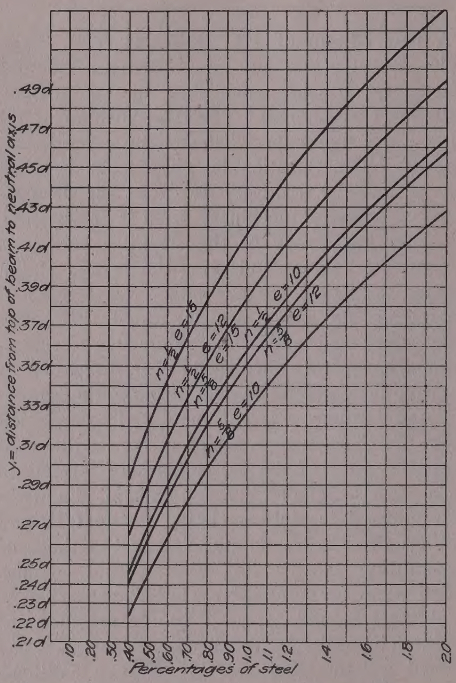


Diagram Giving Position of Neutral Axis.

The formulas which assume the concrete as taking tension are, it seems to me, too complicated for practical designing, and as those of Considère and Johnson are based on the supposition that this tension is uniformly distributed, which is known to be incorrect, the formulas are of questionable value.

Yours truly,

Toronto, April 10. A. W. CONNOR.

SIR: I am obliged to Mr. Connor for pointing out the misprints in my paper, some of which were contained in the advance proof hastily gotten out by the Canadian Society, and I am afraid you must be responsible for the rest. I think Mr. Connor is correct in every case excepting with regard to Prof. Hatt's formula, which is quite correct as it stands, agreeing with the original paper in the "Journal" of the Western Society of Engineers for June, 1904. The discrepancy is simple and results from the nomenclature being different from that used in Considère's formula in my paper. In Prof. Hatt's paper hx = distance of neutral axis from top of beam and hu = distance from top of beam to the centre of the steel which makes the formulas, as they stand, correct. Thanking you for the opportunity of making these corrections and expressing my appreciation of Mr. Connor's careful study, I am,

Yours very truly,

HENRY GOLDMARK.

Montreal, April 20.

FIVE-CENTERED ARCH.

SIR: In reference to the article about the five-centered arch in your issue of April 14, I submit the following method of solution, which, while not original, may be new to some of your readers. The construction, as is readily seen, consists in finding seven points in the circumference of an ellipse by one of its well-known properties, and drawing arcs of circles through those points.

Given the span AB and the rise CE. Draw circles ADB and $A'EB'$. Divide the semi-circles into six equal parts by radii. Vertical and horizontal lines through the points of intersection locate points on the ellipse. The circle through the three points, h, E and f has its center at O. Bisect the lines ih and fg at p and r. Erect perpendiculars at p and r. Their intersections with the radii Oh and Of give the centers P and R. The intersections of the radii Pi and Rg with AB give the centers Q and S.

For an analytical solution, let the span be $2a$ and the rise equal b. Represent the angles at Q, P and O by x, y and z, and the three radii by R, R' and R'' respectively. Then the following equations are readily derived:

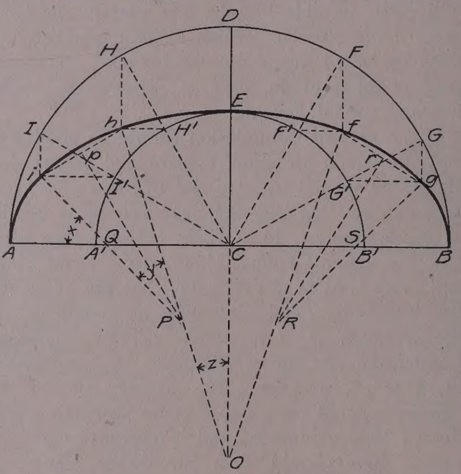


Diagram for Five-Centered Arch.

$$R = (a^2 + b^2 - (a^2 - b^2) \cos \pi/6) \div 2a$$

$$R'' (a^2 + b^2 + (a^2 - b^2) \cos \pi/6) \div 2b$$

$$x + y + z = \pi/2$$

$$\sin x = (b \div R) \sin \pi/6$$

$$\sin z = (a \div R'') \sin \pi/6$$

m = chord ih =

$\sqrt{\ } a^2 (\sin \pi/\frac{1}{3} - \sin \pi/\frac{1}{6})^2 + b^2 (\cos \pi/\frac{1}{3} - \cos \pi/\frac{1}{6})^2$

$R' = \frac{1}{2} m \operatorname{cosec} y/2$

JOHN CLAUSNITZER.

New York, April 21.

THE SOO CANAL TRAFFIC in 1905 was 44,270,680 net tons, 40 per cent. more than in 1904. The number of passengers carried was 54,204, an increase of 44 per cent. The total lockages numbered 13,792, a gain of 34 per cent. About 88 per cent. of the freight traffic and 52 per cent. of the passengers passed through the American canal, which had a working season of 264 days.